

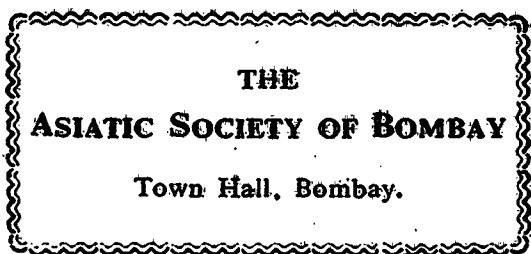


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BULLETINS OF THE GEOLOGICAL SURVEY OF INDIA

SERIES A—ECONOMIC GEOLOGY

No. 26.—LIMESTONE DEPOSITS OF INDIA

BY

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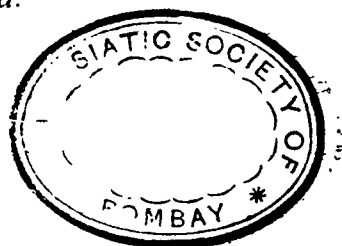
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ABSTRACT

This bulletin gives a detailed account of the specification and distribution of limestone deposits in India. The specification of the limestones for use in metallurgy, cement, lime and glass manufacture etc. are described briefly. The leading producer of limestone in this country is Madhya Pradesh followed by Bihar, Orissa and Madras. The district-wise production figure of limestones of various States as on 1962 are given. A brief outline of the sources of limestones utilised by the existing Iron and Steel and Cement Plants in the country is also given.

A state-wise detailed description of various limestone deposits with their extent, quality and reserve is also included in this volume.

Moderately large reserves of flux-grade limestone (both for blast furnace and steel melting shop) are found in (1) Sundargarh district (Orissa)—133 million tonnes, (2) Shahabad district (Bihar)—60 million tonnes, (3) Mirzapur district (Uttar Pradesh)—50 million tonnes, (4) Rewa district (M.P.)—92 million tonnes, (5) Satna district (M.P.)—85 million tonnes and (6) Durg district (M.P.)—95 million tonnes. Recent investigation has also indicated large reserves in the Gulberga and Belgaum districts of Mysore.

I. INTRODUCTION

Limestone, marble, chalk and whiting contain mainly the mineral calcite (calcium carbonate). The word limestone is often applied loosely to all stratified rocks containing calcium carbonate, or calcium carbonate and magnesium carbonate or a mixture of these two. Marble is a recrystallised limestone and the grain size is coarse. Chalk is fine grained powdery limestone and whiting can be prepared either by grinding fine limestone, marble or chalk or obtained by precipitation from a solution or suspension containing lime. *Kankar* is also calcium carbonate which occurs as irregular concretions in surface soils. Along the coast, calcined sea shells are used as a source of lime or for the manufacture of cement as in Kerala.

Limestone contains besides CaO, variable amounts of iron oxide, alumina, magnesia, silica, phosphorus and sulphur. Limestone is used as such or after calcining in chemical industries like manufacture of lime, cement, alkali, glass, paper, calcium carbide, sugar refining, as a flux in iron and steel industry, and as fillers.

SPECIFICATIONS

Metallurgical purpose.—While considering limestone to be used for metallurgical purpose, the available lime should be considered. The available lime can be obtained by deducting from the total quantity of CaO required to flux the impurities (1 part or per cent of CaO for 1 part or per cent of silica or alumina present). In the Iron and Steel industry, limestone is used in blast furnaces and in steel melting shops. For blast furnaces the percentage of phosphorus should not be more than 0.01 per cent when making low phosphorus iron but for basic iron a large percentage even upto 1.5 per cent is necessary. Sulphur should not exceed 0.5 per cent. Normally in limestone, the quantity does not exceed this limit unless it contains appreciable quantity of pyrite. In the limestone used in steel melting shops, phosphorus and sulphur should be lower than the above figures. Limestone is used for removal of silica and alumina present in the iron ore. Hence normally these constituents should be less in the limestone. In the limestone used in some of the foreign countries, the silica percentage should not exceed 5 per cent in B.F. grade and one per cent in S.M.S. grade. Due to non-availability of such a stone in India, the Indian manufacturers are forced to relax the specifications.

The specifications of limestone used in blast furnaces in India are given below :—

	Tata Iron & Steel Co.	Mysore Iron and Steel Works.	Hindusthan Steel, Rourkela Plant.
CaO% . . .	47.5	48.3	44.5 (minimum)
SiO ₂ % . . .	5.3	6.8	10
Al ₂ O ₃ % . . .	1.3	0.85	1
MgO% . . .	4	1.86	3.5

The specifications of limestone used in steel melting shops are given below :—

	Tata Iron & Steel Co.	Mysore Iron & Steel Works.	Hindusthan Steel, Rourkela plant.
CaO% . . .	48.8	49.6	47.5
SiO ₂ % . . .	3.8	3.57	4.4
Al ₂ O ₃ } % . . .	0.96 } . . .	1.8	1
Fe ₂ O ₃ } . . .	1.13 } . . .		
MgO% . . .	3.8	3	3.5

Cement manufacture.—For the manufacture of cement as per B.S. Specification B.S. 12 : 1958, the limestone should not contain more than 2.5 per cent magnesia, CaO not less than 42 per cent and silica not more than 14.15 per cent. Silica may occur as free quartz or chert when the grinding costs become high. But when it occurs as silicates it is less objectionable. However, in combination with alumina it may occur as clay, and if it is not present in large quantities it is useful in cement manufacture. If the P₂O₅ content of limestone is more than one per cent, it is objectionable as it slows down the setting time. However in most limestones it is normally less than this amount. Iron in the form of oxide, carbonate or silicate in small amounts acts as flux. Sulphur in the form of sulphide or sulphate is not desirable as it may lead to the formations of sulpho-aluminate which is highly expensive. Iron sulphide should not be more than two per cent. It is easier to grind argillaceous limestone than pure limestone. Depending on the quality of clay or shale, the proportions of limestone in mixture for burning Portland cement varies. The CaCO₃ content may be 75 per cent, SO₂+Al₂O₃+Fe₂O 20 per cent, MgO and alkalis five per cent.

Though cement grade limestone can be used straight, the recent trend is to beneficiate it by using a process like froth floatation. This beneficiation to reduce silica, iron oxide and alumina from limestone. The removal of coarse quartz particles decreases grinding costs. Elimination of mica and other ferro-magnesian minerals decreases the objectionable elements of iron and alkalis.

Lime manufacture.—For mortar and plaster, the MgO content should be less and silica content can be ten per cent or more. Argillaceous limestone (18 to 20 per cent clayey matter) is used for the manufacture of hydraulic lime. The limestone should be fairly hard and massive so as to resist any tendency to crushing in the kiln. The size should be less than 7 cm. After allowing for waste and losses due to over-or under-burning in the kilns, roughly two tonnes of limestone are required for one tonne of lime. If water is added to it to convert it to quick lime or slaked lime then its weight will increase by roughly one-third.

Paper manufacture.—Limestone or lime is used in the liquor used for cooking rags and for wood pulp manufacture and finely divided white lime for fillers in paper manufacture. The CaCO₃ content of limestone used in paper manufacture should not be less than 95 per cent and MgO preferably low (less than three per cent), as it is detrimental to sizing of the paper in its later stages. Argillaceous limestones are not suited. The consumption of lime for paper manufacture is higher in India than most countries where purer limes are available and the by-product carbonate sludge is reburnt to be used again. In India high grade limes are not readily available and

silica from bamboo contaminates the sludge when it is not fit for reburning for use again. Roughly one tonne of lime is needed for every three and half tonnes of paper made.

Glass manufacture.—High calcium limestone is needed for making bottle and window glass. Organic matter should not exceed 0.3 per cent. The material should be ground between 20 and 100 mesh. The British Standard Specification of limestone for the manufacture of colourless glass is as follows :—

CaO	55.2 per cent (CaCO ₃ 98.5 per cent).
Fe ₂ O ₃	0.035 per cent acid insolubles including silica.
Organic matter	0.1 per cent.
Manganese, lead, sulphur and phosphorous oxides if present upto 0.1 per cent individually.	
Moisture percentage should not be more than 2 per cent.	

The U.S. Bureau of standards for limestone and lime for glass manufacture are given below :—

	Class 1		Class 2		Class 3	
	Max. per cent.	Min.	Max. per cent.	Min.	Max. per cent.	Min.
CaO+MgO . . .	94	—	—	91	—	83
Fe ₂ O ₃ . . .	0.2	—	1.0	—	1.0	—
Al ₂ O ₃ . . .	3.0	—	5.0	—	5.0	—
SO ₃ +P ₂ O ₅ . . .	1.0	—	1.0	—	1.0	—
SiO ₂ . . .	4.0	—	9.0	—	17.0	—

All the products must pass No. 16 sieve (aperture 1.10 mm.) unless otherwise specified.

For bottle glass manufacture, the limestone may contain upto 0.5 per cent Fe₂O₃, silica and alumina upto 15 per cent and sulphur and phosphorus not greater than 1 per cent.

Sugar industry.—Lime is used either for precipitating impurities from the juices or for precipitating sugar from impurities as in Steffen process. Lime forms insoluble salts with sugar which are split by carbon dioxide which is made at the factories by burning lime.

The U.S. Bureau specifications for lime and limestones for sugar refining are given below :—

	Sugar soluble lime (min) per cent.	MgO (max) per cent.	Loss on ignition (max) per cent.
Limestone for Steffen process.*	90	3	—
Limestone for other processes.*	85	3	—
Quick lime for Steffen process.	90	3	2
Quick lime for other processes.	85	3	5
Lime powder . . .	90	3	2
Hydrated lime . . .	86	3	—

* Limestone is calcined before analysis.

For production of metallic calcium, high grade lime with very little magnesium, strontium, barium and alkalis is required. The alkali metals are undesirable as they may cause the ignition of metallic calcium when the retort is opened.

Alkali manufacture.—In the ammonia-soda process, for each tonne of soda ash produced, 1 to 1.25 tonne of high calcium limestone is required. The limestone should be in lumps from 2 to 10 cm. in diameter. MgO upto 6 per cent is tolerated. Some prefer stone with MgCO_3 at 0.6 per cent. The CaCO_3 content should be 90-99 per cent and $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3 + \text{SiO}_2$ —0.3 per cent. In the Leblanc process, the CaCO_3 content should be 96 per cent. Magnesia, silica and alumina should be in small quantities.

Lime free from clayey matter is used for the manufacture of caustic soda. Available lime should be 85 per cent and magnesia should not be beyond 3 per cent.

Bleaching powder.—For this high calcium limestone without clayey matter is required. CaCO_3 content should be more than 96 per cent, MgO less than 1.5 per cent, SiO_2 —2 per cent, and R_2O_3 —1.1 per cent (out of which Fe_2O_3 should not exceed 0.5 per cent). Manganese and iron should be only in traces as they are detrimental to the quality of the powder. The limestone on burning should give a fat lime which will form fine powder on slaking for twenty to thirty minutes and give a volume of slaked lime three times that of the original lime. The lime should be very fine with an open or porous texture so as to allow full penetration of gases.

Calcium carbide.—Dense massive variety of limestone which will not frit on burning is needed. The lime should not crumble during any part of carbide manufacturing process. Coarsely crystalline limestone become friable on calcining and hence are not useful.

The specifications are given below :—

CaO . . .	—54 per cent (CaCO_3 more than 95 per cent).
SiO_2 . . .	—1 to 3 per cent.
Phosphorus . . .	—0.01 to 0.05 per cent.
MgO . . .	—0.5 per cent.
Fe_2O_3 . . .	—1 per cent.

The impurities, regarded objectionable, include magnesia, alumina, silica, iron oxide, sulphur, phosphorus and alkalis.

A.S.T.M. specification No. C258-52 of quick lime is given below :—

	Per cent
Total lime (CaO)(min)	92
MgO(max)	1.75
SiO_2 (max)	2
$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$ (max)	1
S(max)	0.2
P(max)	0.02
Loss on ignition	4

(Fe_2O_3 should not be more than 0.5 per cent.)

For production of carbondioxide High calcium limestones are used.

Ceramic use.—Calcium carbonate in the form of ground limestone marble, chalk or whiting is used. The powder mixed with water should pass through 140 mesh sieve with 1 per cent residue and 200 mesh with 2 per cent residue. Total carbonate (CaCO_3 and MgCO_3) should not be less than 97 per cent and iron oxide not more than 0.3 per cent, silica 2 per cent, sulphur trioxide 0.1 per cent. In Grade 1 stone, the MgCO_3 should not be more than 1 per cent and in Grade 2, may be upto 8 per cent.

Textile industry.—The composition of lime to be used is given below :—

CaO —94 per cent.

MgO (max.)—3 per cent

$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$ (max)—2 per cent.

SiO_2 and insoluble matter (max)—2.5 per cent.

(All the above constituents to be calculated on a non-volatile basis)

The maximum permissible percentage of carbon dioxide at the place of manufacture is 3 in hydrated lime and 5 in quick lime and at other places 5 in hydrated lime and 7 in quick lime. Lime containing readily soluble iron and considerable amount of nonhydrated magnesia should not be used.

Leather Dressing.—Lime made out of high calcium limestone is used. Except for morocco leathër, magnesia is regarded as objectionable. Iron and other metallic impurities should be low.

For paints, distempers and allied materials.—The calcined lime should be perfectly white, of low density and of great fineness. Some form of precipitated chalk or CaCO_3 is often used. Hydrate lime for use in varnish manufacture should have a high content of CaO with low magnesia, and the material should not darken the varnish.

Silica brick manufacture.—According to A.S.T.M. specification 49-57, the quick lime or slaked lime should contain not less than 90 per cent CaO , and the following percentage maxima calculated on non-volatile basis : MgO —4.5, $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$ —1.5, SiO_2 and insoluble matter 3. CO_2 should not exceed 10 per cent if sampled elsewhere and 5 per cent if sampled at the site of production, 99 per cent of the lime should pass through No. 30 (590 micron) sieve and 95 per cent should pass through No. 200 (74 micron) sieve. Rapidity in slacking and fineness of the hydrated product are additional desirable qualities.

Mineral treatment process.—For use in floatation, the lime should settle slowly from suspension in water, and the CaO content should be more than 90 per cent. Magnesian lime is not suitable.

For rubber, soap and allied industries.—Chalk whiting or recovered CaCO_3 are used in fine powdery form 90 per cent of which should pass through a 300 mesh sieve.

Water treatment.—Limestone is converted either into quick lime or hydrated lime for use in water treatment. Hydrated lime for water softening should not contain less than 68.1 per cent of available lime and it should be free from ash and dirt. The quick lime should contain more than 90 per cent available lime.

Sewage treatment.—Limestone is used in filter beds. The stone should be able to withstand weathering and should be free from clay, pyrites, shale, chert and ochre.

Agricultural uses.—Large quantities of ground limestone, quick and hydrated lime are used in other countries for ameliorating soil conditions.

Road paving mixtures.—Limestone can be used for road construction in street asphalts, and asphalt concrete.

Other chemical uses.—Various grades of lime are used as neutralising agents in many chemical processes like manufacture of soap, arsenical insecticide, glue, gelatin, citric-acid, starch, sugar and phenol. The lime should be free from clayey material, silica, alumina and iron oxide. In the preparation of various chemicals like chromates, dichromates etc., in coke and gas works and food products etc., high calcium limestones are preferred.

Rock and Mineral wool.—Impure limestone can be used. The rock should be hard and massive and should possess sufficient strength to support the weight of the charge without packing and blocking the escape of gases released from the furnace. Apparently there is a wide variation in the chemical composition of mixes used.

Lithographic printing.—Fine grained and compact limestone of uniform texture is required. The stone should be free from calcareous crystallisation, vermiculations, siliceous specks and conspicuous veins. The fracture should have glassy surface free from grains and be generally conchoidal. SiO_2 , Al_2O_3 plus Fe_2O_3 should not exceed 5 per cent. Nitric acid should completely dissolve the stone leaving only an insignificant residue.

PRESENT PRODUCTION

Madhya Pradesh is the leading producer of limestone. Bihar, Orissa and Madras States are next important producers in the order of production. The production figures of limestone of all grades from different states are given in the following table :—

State	District	1959	1960	1961	1962
Andhra Pradesh	Adilabad . . .	201,549	230,741	290,354	..
	Anantapur . . .	5,754	4,586	1,861	..
	Guntur . . .	508,408	492,109	576,080	..
	Hyderabad . . .	..	115,192	110,913	..
	Kurnool . . .	61,855	77,774	85,784	..
	Srikakulam . . .	6,703	..	..	..
Total . .		909,762	920,402	1,073,992	1,284,088
Assam . . .	Khasi and Jaintia Hills.	61,040	49,216	105,212	..
	Total . .	61,040	49,216	105,212	79,204
West Bengal . . .	Jalpaiguri . . .	2,442	45	120	..
	Purulia . . .	2,439	2,766	7,868	..
	Total . .	4,881	2,811	7,988	29,109

State	District	1959	1960	1961	1962
Bihar	Hazariabagh . . .	27,182	14,182	58,064	..
	Palamanu . . .	..	..	31,366	..
	Ranchi . . .	247,652	271,498	237,457	..
	Shahabad . . .	1,005,244	1,245,441	1,232,446	..
	Singhbhum . . .	473,737	520,071	469,761	..
	Total	1,753,815	2,051,192	2,029,094	2,213,236
Gujarat . . .	Baroda . . .	..	1,600	2,313	..
	Jamnagar . . .	46,618	186,122	160,424	..
	Kaira . . .	373,777	372,865	382,934	..
	Sorath . . .	19,411	125,307	218,208	..
	Total	439,806	685,894	763,874	1,180,782
Madhya Pradesh . . .	Bilaspur . . .	..	3,374	..	..
	Durg . . .	178,248	554,884	702,947	..
	Jabalpur . . .	646,704	777,178	843,162	..
	Morena . . .	92,968	85,059	82,349	..
	Raipur . . .	272	122	266	..
	Satna . . .	492,352	569,723	704,067	..
	Total	1,410,544	1,990,340	2,332,781	3,063,718
Madras . . .	Coimbatore . . .	425,416	440,396	494,387	..
	Ramanathpuram . . .	..	17,313	39,331	..
	Salem . . .	12,233	12,204	13,839	..
	Tiruchirappalli . . .	451,464	522,579	646,547	..
	Tirunelveli . . .	335,215	628,457	673,560	..
	Total	1,274,328	1,620,949	1,867,664	2,038,217
Maharashtra . . .	Yeotmal . . .	18,918	35,265	29,489	..
	Total	18,918	35,265	29,489	44,126
Mysore . . .	Gulbarga . . .	833,405	899,785	917,606	..
	Shimoga . . .	142,467	133,667	134,882	..
	Chitaldrug . . .	..	..	127	..
	Total	975,872	1,033,452	1,052,615	1,291,845
Orissa . . .	Sundergarh . . .	1,556,318	1,768,010	2,192,514	..
	Total	1,556,318	1,768,010	2,192,514	2,205,969

State	District	1959	1960	1961	1962
Punjab	Ambala	591,211	604,027	656,348	..
	Total	591,211	604,027	656,348	625,288
Rajasthan	Bundi	489,598	349,557	494,572	..
	Kotah	95,109	94,210	..	..
	Pali	22,336	16,587	..	..
	Sawai-Madhopur	793,407	1,002,191	1,089,070	..
	Sikar	6,418	17,122	41,389	..
	Sirohi	10,424	19,235	15,801	..
	Total	1,417,382	1,588,902	1,649,841	1,645,396
Uttar Pradesh	Chamoli-Garhwal	..	1,025	30	..
	Dehradun	66,922	46,523	110,044	..
	Mirzapur	350,697	330,487	458,338	..
	Total	417,619	378,035	577,412	617,318
ALL INDIA TOTAL		10,831,496	12,728,495	14,338,824	16,318,385

FUTURE DEMAND

The Perspective Planning division of the Planning Commission after taking into account the deliberations of several working groups finalised the anticipated production figures for a 15 year period (1960-1975). These studies show that by 1975 the production of limestone will increase at five times that of 1960. The anticipated industry-wise utilisation of the limestone as estimated by Planning Commission is given below :—

Requirement of limestone in thousand tonnes

Consuming industries	1960 Production	1965-1966 Capacity	1965-1966 Production	1970-1971 Capacity	1970-1971 Production	1971-1976 Capacity	1971-1976 Production
1. Cement	11,310	10,720	18,650	37,700	33,350	58,000	52,200
2. Blast furnace	2,100	4,900	4,900	10,000	10,000	16,850	16,880
3. Sugar	317	439	439	515	495	615	595
4. (i) Soda ash	160	396	374	825	660	1,265	1,100
(ii) Caustic soda-chemical.	5	4	4	12	12	20	20
5. Glass	7	15	12	29	22	30	29
6. Calcium Carbide	20	118	110	250	220	500	460
7. Nitrolime fertilisers.	320	560	560	800	800	1,200	1,200
8. Ferro-manganese	43	100	100	175	175	250	250
9. Paper and paper board inclusive of newsprint.	287	599	510	1,512	1,239	2,519	2,148
10. Construction projects	920	1,553	1,553	2,673	2,673	4,313	4,313
Total requirement	15,489	28,404	27,412	54,491	49,646	85,562	79,165

SOURCES OF SUPPLY FOR THE EXISTING AND PROJECTED IRON AND STEEL AND CEMENT PLANTS.

Limestone required for the Iron and Steel industry is of two types (1) for use in blast furnace and (2) for use in steel melting shops. The requirement of S.M.S. grade variety of lime is roughly one-fifth of the total requirement of limestone. According to Johnstone (1961), silica should not be greater than 5 per cent for blast furnace grade limestone and 1 per cent for S.M.S. grade limestone. As such limestone is not available, the Tata Iron and Steel Co. used limestone with acid insolubles upto 7.5 per cent in blast furnace and upto 5 per cent in Steel Melting Shops. With the expanding steel industry, proved reserves even of this grade became scarce, and one of the methods to overcome the scarcity was to relax specifications (upto 12 per cent insolubles for blast furnace grade and 7 per cent insoluble for S.M.S. grade). As the bulk of the requirement is of blast furnace grade, it is very necessary that adequate reserves of B.F. grade limestone should be proved close to (preferably within 250 km) the steel plants. S.M.S. grade limestone on the other hand can be met with from deposits located some distance away from the steel plants. It is tentatively considered that all efforts should be made to meet the requirement from deposits located within a maximum distance of 500 km from the location of the steel plants.

The areas of possible location of future steel plants including the existing ones are West Bengal, Bihar, Orissa, Madhya Pradesh, Andhra Pradesh, Mysore, Madras and Goa. Limestone bearing areas are known to occur in all the states except Goa. In considering deposits for flux-grade limestone, the requirement of limestone for cement plants and chemical industries already installed in these states which draw their requirements from these deposits should also be taken into account. Except in a few deposits, systematic work was not carried before for selection of blocks for detailed exploration. A top priority has been given to the investigation of limestone deposits and a detailed programme was drawn up by the Indian Bureau of Mines for investigation of limestone deposits in Shahabad and Palamau districts, Bihar; Satna, Rewa and Bilaspur districts, Madhya Pradesh and in Mirzapur district, Uttar Pradesh. The department is also carrying out investigations in Andhra Pradesh and Mysore for locating blocks for detailed proving. The results so far achieved in respect of some of these deposits in the Bhilai Iron & Steel belt and Bailadila-Visakhapatnam and Bellary-Hospet areas and the status of knowledge in respect of deposits near the existing ones and for those near cement plants are given in the following tables:—

A. Ungapur-Burnpur-Iltanagar-Rourkela-Bokaro-Bhilai Iron & Steel Belt.

Area.	Estimated Reserves of flux grade.	Remarks.
ORISSA STATE		
<i>Sundergarh district</i>		
Birmitrapur area	100 million tonnes of limestone with less than 10 per cent insolubles.	By detailed examination of the analytical data of Bird & Co., I.B.M. estimate of these reserves which confirm the G.S.I. estimate of 107 million tonnes. As the distribution of S.M.S. grade is erratic and as selective quarrying has to be done for its recovery, it is better to draw from this deposit B.F. grade only.
Lanjiberna	16 million tonnes with insolubles less than 8 per cent.	Unless additional reserves are proved, this deposit should be left for the exploitation of the existing cement factory with an installed capacity of 370,800 tonnes.
Hathilari, Purnapani and Ghatitangar areas.	17.4 million tonnes with insolubles less than 8 per cent.	
BIHAR STATE		
<i>Shahabad district</i>		
Banjari, Uttni, Murli hill; Baulia-Chunahatta, Dhanauti, Dabua, Chutia, Gatiahi, Doma, Hariara areas.	S. M. S. Grade 12-million tonnes. B. F. grade 48 million tonnes. Cement grade 30 million tonnes.	These estimates are confined to the exposed areas only. There are four cement factories with an installed capacity of one million tonne in this area. The existing plants should be assured of 45 million tonnes of cement grade limestone. Limestone in this area occurs as bands of distinct quality. The top 3 metre flux grade band has to be mined and mixed with other bands in order to obtain a blend suitable for the requirement of cement plants. In view of this Mahapatra and Prasada Rao (1963) opined that the Shahabad limestone area can not be relied upon as an important source for flux grade limestone.

BIHAR STATE

Palamu district

Bhaunathpur area

On the basis of detailed surface sampling and mapping investigation of limestone bands in the Konmunda, Dhanimunda, Gargawan, Ghagra and Gorda blocks by G. S. I., it was found that there are no suitable free flux grade prospects other than those under lease to Hindusthan Steel Ltd., which was already prospected by them by drilling.

UTTAR PRADESH

Mirzapur district

Robertsganj Tehsil

Major and easily accessible deposits are under active exploitation by the Uttar Pradesh State Govt. Cement factory (quarries at Gurma). Sizeable adjacent areas are also under lease to them. Exploration by G. S. I. for flux grade limestone is restricted to the eastern part of this belt in the Mirzapur district lying to the north of Son River, extending from Kanch ($24^{\circ}29'$: $83^{\circ}07'$) to Pokharia ($24^{\circ}32'$: $83^{\circ}31'$) over a distance of 42 km. This belt is divided into Sectors I to IV from east to west. As a result of preliminary survey, B. F. Grade limestone has been located in Pokharia, Argarh and Chandni blocks of Sector I with thickness of limestone bearing horizon varying from 9 to 15 m. Drilling has been completed in the Pokharia block and exploration is in progress in Chandni and Kanchi blocks. A major part of the limestone is of B. F. Grade.

Area.	Estimated Reserves of flux grade.	Remarks.
UTTAR PRADESH		
Kajrahat area	50 million tonnes (tentative estimate) . .	Detailed exploration is being carried by the Directorate of Geology and Mining, Government of Uttar Pradesh in Kota, Kajrahat and Dalla Sectors. It is reported that large quantities of B. F. Grade limestone are available and that S. M. S. grade reserves are meagre.
MADHYA PRADESH		
<i>Rewa district</i>		
Bela block between Baijnath and Madhapur.	S. M. S. Grade—19 million tonnes	Tentative figure.
	B. F. Grade—33 million tonnes	
Bankinyan block	S. M. S. and B. F. Grade—40 million tonnes	Detailed exploration by drilling is completed by G. S. I. The block is being handed over to I. B. M. for further work.
<i>Satna district</i>		Work by G. S. I. is in progress.
	B. F. & S. M. S. Grade—85 million tonnes (within and around existing quarries) Probable reserves within 590 sq. km. of potential area—2,400 million tonnes.	The Satna area is expected to contain large reserves of S. M. S. grade. Though a large part of the area is under lease, many free areas also exist.
<i>Jabalpur district</i>		
Niwara area		As a result of work carried out by I. B. M., the existence of a large deposit of flux grade limestone brought to light has been Work is in progress.
Jukehri	7 million tonnes of both Grades . .	The reserves estimated are within and around existing quarries. One cement factory is utilising limestone from this area.

Area.	Estimated Reserves of flux grade.	Remarks.
MADHYA PRADESH		
<i>Drug district</i>		
Meresars area	28 million tonnes of B. F. Grade	I. B. M.'s estimate.
Deorjal area	67 million tonnes of B. F. Grade	I. B. M.'s estimate.
Nandagaon		Near Nandagaon, the potential flux grade limestone area stretches for 48 km. from Khalewa to Arjuni.
<i>Raipur district</i>		Potential flux grade limestone areas exist in this district. Detailed investigations have to be carried out for delineating blocks.
<i>Bilaspur district</i>		
Chilhati and Pachperi		Work by G. S. I. in this area is in progress.
<i>Bastar district</i>		
Kangar Valley limestone belt :—		
Majhar Dongri	B. F. Grade—6.4 million tonnes	Flux grade limestone band is 8 m. thick and occurs under 30 to 50 m. thick overburden of cement grade limestone.
Gadia Dongri	B. F. Grade—2.1 million tonnes	Flux grade band is 6 m. thick and occurs below 30 m thick overburden of cement grade limestone.

Estimated Reserves of flux grade.

Area.

Remarks.

MADHYA PRADESH

Gupensar Dongri . . . B. F. Grade—4 million tonnes . . . Flux grade band is 10 m. thick and occurs below an overburden of cement grade limestone whose thickness is over 50 m. Though all these three deposits occur close to the DBK railway line which is under construction, the utilisation of these bands depends on the utilisation of top cement grade limestone bands.

Sukma area : Goula and West of Kotta-
metta. B. F. Grade—1.4 million tonnes . . . Working these deposits may involve problems of flooding in the quarries as the deposits occur along the banks of Sabari river.

ANDHRA PRADESH

Visakhapatnam district :—

Bona S.M.S. and B.F. Grade—3 million tonnes . . . A major portion of this reserve will not be available for exploitation as the D. B. K. railway line, which is under construction, passes over this deposit.

Kothiguda The band is 1500 m. long and 45 m. wide. Part of this band is of S. M. S. grade I, investigation by G. S. I. is in progress.

Krishna district

Jaggayyapeta and Jayantipuram area . . . Reserves likely to be large . . . A limestone band (top 7.5 metres of which is of blast furnace grade) 150 to 180 metres wide extends over a distance of 16 km. in this area. The G.S.I. is at present investigating this band. The reserves are likely to be large. This band may extend westwards to Wazirabad and south-eastwards, into Piduguralla, Karempudi and Machherla areas.

B. For the proposed Iron & Steel mill in the Bellary-Hospet reg. on.

Area.

Estimated Reserves of flux grade.

Remarks.

ANDHRA PRADESH

Bijapur district :

Mudhol area :—(1) Chinchakundi Budruk ($16^{\circ}15'30''$: $75^{\circ}18'20''$).

(2) Jambgi Budmuk ($16^{\circ}15'75''$: $75^{\circ}21'30''$);

(3) Petalur ($16^{\circ}14'75''$: $75^{\circ}19'15''$);

(4) Bamenbudni ($16^{\circ}12'30''$: $75^{\circ}17'$);

(5) Muddapur ($16^{\circ}14'75''$: $75^{\circ}25'$);

(6) Timmapur ($16^{\circ}13'30''$: $75^{\circ}21'$);

(7) Chitrabhanakot ($16^{\circ}12'45''$: $75^{\circ}23'$);

(8) Chandapur ($16^{\circ}11'75''$: $75^{\circ}22'30''$);

(9) Lokapur ($16^{\circ}09'30''$: $75^{\circ}22'$);

(10) Kejjadoni ($16^{\circ}10'30''$: $75^{\circ}27'$);

(11) Lokshonabatti ($16^{\circ}19'75''$: $75^{\circ}21'$);

(12) Varchagel ($16^{\circ}08'75''$: $75^{\circ}21'30''$);

(13) Mallapur ($16^{\circ}08'45''$: $75^{\circ}19'$);

Area.	Estimated reserves of flux grade.	Remarks.
ANDHRA PRADESH		
<i>Gadabger district</i>	Large reserves	In the Mudhol area the presence of B.F. and S.M.S. Grade limestone is inferred from the analytical results of earlier work. In a preliminary sampling survey just completed, the G.S.I. collected groove samples from bands near these villages for selecting suitable blocks for further property. The analytical work is still in progress. Extensive spreads of limestone occur in a belt over 160 km. long. The limestone bands are reported to occur over an area of 1500 sq. km. The Shahabad Cement factory draws its supplies from a small part of this belt. The available chemical analysis show that large reserves of B.F. Grade limestone can be expected from this area. Initial preliminary sampling has to be done for selection of suitable blocks for further proving.
<i>Belgaum district</i>		
Nagargah area	Probable reserves 50 million tonnes (tentative figure).	From the preliminary data, the presence of B.F. grade limestone can be inferred here. A cement plant is expected to be erected here.

Table No. 1.—Cement Factories, their existing capacity, limestone deposits in the vicinity and their estimated reserves.

Serial No.	Name and address of Firm.	Location of Plant.	Existing capacity per annum.	Limestone deposits in the vicinity.	Reserves.
ANDHRA PRADESH—					
1.	Ms. Andhra Cement company Ltd., P. B. No. 301, Buckinghampet P. O. Vijaywada-2.	Vijaywada . . .	201,140	Nadikude-Piduguralle area	Not estimated.
2.	Ms. K. C. P. Ltd., 38, Mount Road, Madras.	Macherla . . .	259,970	Gangalagunta and Gotti- palle.	124.5 m. tonnes.
3.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Kistna Tadopally . . .	259,050	Sikarampuram and Kaja- Piduguralle area.	Not estimated.
4.	Ditto . . .	Mancherla . . .	335,240	....	Reserves of limestone are expected to be large.
5.	Ms. Panyam Cement & Mineral Industries Ltd., Cement Nagar P. O., via-Bugganapalli R. S., Kurnool Distt.	Panyam . . .	63,650	Bugganapalle . . .	Reserves not estimated for the specific area, but the reserves of Kurnool distt. are very large.
BIHAR—					
6.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Chaibasa . . .	487,620	Rajanka . . .	Small deposit.
7.	Ditto . . .	Sindri . . .	304,760	....	Manufacture of cement as a by-product of fertiliser.
8.	Ditto . . .	Khalari . . .	101,590	Khalari, Bukbhuka, Churi and Sar'e	Small deposit.

Serial No.	Name and address of Firm.	Location of the Plant.	Existing capacity per annum.	Limestone deposits in the vicinity.	Reserves.]
BIHAR—contd.					
9.	Ms. Rohtas Industries Ltd., Dalmianagar, Bihar.	Dalmianagar	335,240	Ramdihra, Rohtas hills.	Banjari,
10.	Ms. Ashoka Cement Ltd., Dalmianagar, Bihar.	Dalmianagar	284,440		
11.	Ms. Kalyanpur Lime and Cement Works Ltd., Edward House, P. O. Arrah (E. Rly.), Bihar.	Banjari	146,290	Banjari	Reserves, in the exposed area, of cement Grade limestone 90 m. tonnes.
12.	Ms. Sone Valley Portland Cement Co., Ltd., 11, Clive Row, Calcutta-1.	Japla	253,970	Japla	
GUJARAT—					
13.	Ms. Shree Digvijay Cement Co. Ltd., Shrinivas House, Wadby Road, Fort, Bombay.	Sikka	436,830	Gope (Bhaunagar)	Not estimated.
14.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Dwarka	223,490	Dwarka	Not estimated.
15.	Ditto	Porbandar	42,670	Aditanya and Ranavao, Junagadh.	Not estimated.
16.	Ditto	Sevalia	203,180		
17.	Ms. Saurashtra Cement and Chemical Industries Ltd., Ranavav-2, Gujarat State.	Ranavav	203,180	Ranavav, Junagadh.]	Reserves not estimated.

Serial No.	Name and address of Firm.	Location of the Plant.	Existing capacity per annum.	Limestone deposits in the vicinity.	Reserves.
KERALA—					
18.	Ms. Travancore Cement Ltd., P. B. No. 35, Kottayam.	Kottayam . . .	50,790	Shells from Vembanad Lake.	The reserves in 15 sq. km. area are estimated at 2 to 2.5 million tonnes.
MADHYA PRADESH—					
19.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Kymore . . .	582,000	Jukehi, Barapara, Khalwara, Mahgaon & Katni.	Jukehi reserves 7 million tonnes.
20.	ditto.	Barmor . . .	60,950	Kalaras, Somei & Ochan (Morena dist.).	Not estimated.
21.	Ms. Birla Jute Mfg. Co. Ltd., 8, India Exchange Place, Calcutta.	Satna . . .	251,430	Satna . . .	85 million tonnes.
MADRAS—					
22.	Ms. Dalmia Cements Ltd., (Bharat), Scindia House, New Delhi.	Dalmiapuram in Tiruchirappally.	410,050	Kalakudi and Vadugurpet	Not estimated. One exposure is 2 km. by 300 m. and the other 2.7 km. by 800 m.
23.	Ms. India Cements Ltd., 11/12, Second Line, Beach, Madras.	Talaiyuthu . . .	462,630	Talaiyuthu . . .	5.9 million tonnes.
24.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Medukarai . . .	284,440	Medukarai and Etimadai	Not estimated. Reserves in 3 new bands is 43 million tonnes.

Serial No.	Name and address of Firm.	Location of the Plant.	Existing capacity per annum.	Limestone deposits in the vicinity.	Reserves.
MADRAS—					
25.	Ms. Madras Cements Ltd., Rammandrem, Rajepalayam dist. Rannathpuram.	Tulukeppatt	97,050	Pendalagudi, Palavalattam	4-665 m. tonnes.
MYSORE—					
26.	Ms. Mysore Iron & Steel Works Bhadravati, Mysore State.	Bhadravati	99,560	Bhadigund	3 million tonnes.
27.	Ms. Bagalkot Cement Co., Ltd., Veer Nariman Road, Fort, Bombay.	Bagalkot	203,180	Bagalkot	Not estimated (6 km. long band with a width of 500 metres)
28.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Shahabad	573,970	Bankur of Gulberge district.	Limestone area is 1500 sq. km. with average thickness of about 90 m.
29.	Ms. Mysore Cements Ltd., 19, Race Course Road, P. B. No. 115, Bangalore.	Ammasandra Tumkur.	101,590		Not estimated.
ORISSA—					
30.	Ms. Orissa Cements Ltd., Scindia House, New Delhi.	Rajgangpur	370,800	Lanjiberna	16 million tonnes.

Serial No.	Name and address of Firm.	Location of the Plant.	Existing capacity per annum.	Limestone deposits in the vicinity.	Reserves.
PUNJAB—					
31.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Surajpur . . .	408,360	Malla hills . . .	20 million tonnes.
32.	Ms. Dalmia Dadri Cement Co., Ltd., 10, Daryaganj, Delhi.	Dalmia Dadri . . .	238,790	Local Kanhar . . .	....
RAJASTHAN—					
33.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Lakheri . . .	365,710	Garunpura and the area between Lakheri and Chaumali.	Extensive deposit.
34.	Ms. Jaipur Udyog Ltd., 5, Parliament Street, New Delhi.	Sawwai Madhopur . . .	818,800	....	100 million tonnes.
UTTAR PRADESH—					
35.	Director, U. P. Govt. Cement Factory, Churk, Mirzapur.	Churk . . .	469,340	Markundi . . .	25 million tonnes.
JAMMU & KASHMIR—					
36.	Ms. J. & K. Minerals Ltd., Srinagar	Wuyan . . .	20,000	Wuyan . . .	4.5 million tonnes.

TABLE No. 2.—*Cement plants under construction.*

Serial. No.	Name of the firm.	Location of the plant.	Annual capacity in metric tonnes.	Year of Imple- mentation.	Limestone deposits in the vicinity.	Reserves.
ANDHRA PRADESH—						
1.	Ms.A. K.Cement Wazirabad Miriylguda <i>taluk</i> Nalgonda Dt.Andhra.	Bhongir	167,620	1965-66	No deposit in the immediate vicinity.	Not estimated.
MADHYA PRADESH—						
2.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Jamal	543,650	1964-65	Jamal Dhaur, Drug Dt.	21 million tonnes in the entire belt.
3.	Ms. Kohli Finance Corpn. Raipur..	Raipur	300,000	1965-66	The limestone bands of Raipur Dt.	17.5 million tonnes.
MADRAS—						
4.	Ms. Indian Cement Co., Ltd., 11/12, Second Line Beach Madras.	Sankridrug	167,620	1963-46	Maveli-Palaiyam- Puttalakuttai and Iveli.	0.1 million tonnes.
5.	Ms. Raja Muttiah Chettia of Chettinad, Chettinad House, Annamalaiapuram, Madras-28.	Karur	167,620	1965-66 (1st stage)	Alinagarāṁ-Tara- kampatti, Kiranur,	0.5 million tonnes.

Serial No.	Name of the firm.	Location of the plant.	Annual capacity in metric tonnes.	Year of Implementation.	Limestone deposits in the vicinity.	Reserves.
MYSORE—						
6.	Ms. Associated Cement Co. Ltd., 121, Queens Road, Bombay.	Wadi	400,000	Beyond 1965-66	Bhima limestone patches around Wadi.	Extensive limestone bearing area 1500 sq. km.
7.	Ms. Shree V. T. Magadi Nagargali, Belgaum dt.	Nagargali	167,620	Ditto.	Nagargali	Preliminary estimate of probable reserves is 50-55 million tonnes.
ORISSA—						
8.	Ms. Orissa Industrial Development Corpn., Industries Deptt, Bhuvaneswar.	Sambalpur	406,360	1965-66	Dungri-Banjipalli	The Dungri-Banjipalli limestone area is 13 km. long and 1.5 km. wide.
RAJASTHAN—						
9.	Ms. Birla Jute Mfg. Co. Ltd., India Exchange Place, Calcutta-1.	Chittorgarh	167,620	1965-66	Bhima, Senth, Segwa etc.	335 million tonnes.
UTTAR PRADESH—						
10.	Ms. U. P. Govt. Cement Factory, Churk, Mirzapur.	Chopan	400,000	Beyond 1965-66	Markundi	25 million tonnes.
JAMMU & KASHMIR—						
11.	Ms. J. & K. Minerals Ltd., Srinagar, Kashmir,	Riasi	103,180	1965-66	Salal to Kanthan	10 million tonnes.

BENEFICIATION

The Associated Cement Company at their Khalari works are using non-metallic froth floatation as patented by Breerwood for beneficiating the inferior grade limestone deposits at Khalari which have excessive impurities of silica and magnesia. The process involves a combination of grinding, classification, floatation and thickening methods, each adopted to suit the specifications of the type of cement required. The Khalari limestone consists of crystalline and very fine-grained varieties. The crystalline part contains well-defined calcite crystals interspaced with minor dolomite and quartz crystals. The fine-grained part consists of pyroxenes, amphiboles, hornblende, biotite and muscovite. The average chemical composition of limestone and the beneficiated concentrates are given below (A.C.C. 1955).

	Limestone per cent.	Beneficiated concentrate per cent.
Insoluble SiO_2	24.4	8.4
Al_2O_3	4.3	1.4
Fe_2O_3	1.4	0.7
CaO	35.8	48.7
MgO	5.7	2.7
Loss on ignition	28.2	37.8
Total .	99.8	99.7

The flux grade limestone should be lumpy. The impurities to be discarded are acid insolubles (alumina and silica) in limestone to be used in Iron and Steel industry while in the case of cement industry they are magnesia and acid insolubles. The National Metallurgical laboratory is attempting to beneficiate limestone, using froth floatation. This results in size degradation and the powder concentrates can not be used as such. These concentrates should be agglomerated for use in the blast furnaces. The technical feasibility, economics and behaviour of agglomerates at high temperatures and in a reducing atmosphere which are the prevailing conditions in blast furnace have to be studied in detail for assessing the potentialities of the beneficiation methods.

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REFERENCES

- AC.C., 1955.—Beneficiation of limestone at A.C.C. Khalati Works by Froth Flotation. *Indian Minerals*. Vol. IX, No. 2, pp. 118-121.
- JOHNSTONE S.J and JOHNSTONE M.G.—1961.—Limestone, chalk and whiting. Minerals for the chemical and allied industries. pp. 293-326. Chapman & Hall, Second edition.
- Mahapatra K. S. and Prasada Rao G.H.S.V.—1963.—Gaps in basic knowledge unpublished note circulated at the meeting of sub-group to identify gaps in basic knowledge, Planning Group Meeting, Ministry of Steel, Mines and Heavy Engineering,—November, 1963.
- Varma S. P.—1963.—“Extract from D.O letter No. MI/CEM/MISC/4/63-16792 dated 7th December, 1963 to Shri C. S V. Rao, Deputy Secretary, Ministry of Steel, Mines and Heavy Engineering in connection with the meeting of sub-group to identify gaps in basic knowledge.

DESCRIPTION OF DEPOSITS

The available information is summarised in the following pages state-wise. This summary shows that most of the data on many deposits are of a preliminary nature. The programme of mapping and of surface sampling which is now in progress should be further intensified for selection of blocks for detailed proving.

ANDHRA PRADESH

Adilabad District

The limestone deposits are known to occur in the Penganga series. According to P. V. Rao (Krishnan, 1954*b*) fine-grained limestone quarries occur at Bhimsari ($19^{\circ}42' : 78^{\circ}32'$), four kilometres N.N.W. of Adilabad. These limestones are used as paving stones.

P. V. Rao (Krishnan, 1958*b*) noted occurrence of two limestone bearing areas—one east of Gondipet ($19^{\circ}03' : 79^{\circ}27'$) and the other north and south of the hills Δ 978 ($18^{\circ}54' : 79^{\circ}42'$). The limestone in the former area is impure, containing about 70 per cent CaCO_3 and less than one per cent MgCO_3 . The limestone of the latter area is dolomitic in nature, containing 40 per cent MgCO_3 and 55 per cent CaCO_3 . Rao also recorded that some of the limestone boulders found in the Talchir boulder beds are burnt locally for making lime.

Anantapur District

M. S. Venkatram and M. S. Balasundaram (1952) investigated the Vempalle limestone belt to the west of Muttsukota ($14^{\circ}51' : 77^{\circ}53'$) and Rayalcheruvu ($15^{\circ}03' : 77^{\circ}49'$). The belt extends further northwards slightly reduced in lateral extent in the region east of Dhone ($15^{\circ}24' : 77^{\circ}53'$) in the Kurnool district. Out of 16 analyses, eight show insolubles less than ten per cent. The range in chemical composition in these eight samples is given below :—

Si_2O or insoluble	Al_2O_3	Fe_2O_3	MgO	CaO
0.54%—7.12%	0.30%—1.60%	trace—2.05%	0.78%—21.24%	25.56%—52.63%

Kankar derived from the alteration of the Vempalle limestones occurs at four kilometres north-west of Daditota ($14^{\circ}36' : 77^{\circ}58'$) and four kilometres east of Chilavaripalle ($14^{\circ}38' : 77^{\circ}54'$). These occurrences occupy an area of 152 m. by 30.5 m. and 76 m. by 15.2 m. respectively. It is used locally for lime manufacture.

According to Krishnan (1951) a large stretch of tufaceous limestone of good quality is found on the hill side 5.6 km. north of Kona Uppalapadu ($15^{\circ}06' : 77^{\circ}54'$).

C. K. R. Sastry (Krishnan, 1951) recorded the occurrence of narrow and discontinuous veins of calcite associated with basic dykes in the Marutla Reserved Forest 3.2 km. south-west of Murikinillapalli ($14^{\circ}50' : 77^{\circ}30'$). They are 80 to 90 cm. wide. They are not transparent for use in the optical glass industry.

Sastry also recorded the occurrence of *kankar* over an area of about 46,500 sq. m. about 1.5 km. west of Pamidi Railway station ($14^{\circ}58' : 77^{\circ}34'$). Another deposit near Kamalapuram ($14^{\circ}53' : 77^{\circ}32'$) occurs over an area of 8,400 sq. m. Their probable depths as judged from abandoned pits is about 1.5 to 3 m. These deposits can support a local lime burning industry.

Cuddapah District

M. S. Venkatram and M. S. Balasundaram (1952) investigated the Vempalle limestone belt. In the Cuddapah district, it starts from about 10 km. south-east of Guvvalacheruvu ($14^{\circ}18' : 78^{\circ}45'$) as a thin band and gradually widens from 4.8 to 6.4 kms. in the area stretching across Nandimandalam ($14^{\circ}24' : 78^{\circ}32'$), Vempalle ($14^{\circ}22' : 78^{\circ}28'$), south of Pulivendla ($14^{\circ}25' : 78^{\circ}14'$) to the west of Mutssukota ($14^{\circ}51' : 77^{\circ}53'$) in the Anantapur district.

Out of 12 analyses, six show insolubles less than ten per cent. The range in chemical composition in these six samples is given below :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO
3.72—7.56%	0.40—2.00%	0.80—2.01%	18.07—20.56%	28.27—29.76%

N. V. B. S. Dutt (1962) investigated the limestone deposits of the Kurnool system of this district. The details about the quality and reserves are given at page 28:

East Godavari District

V. Subramanyam (1944-45) recorded two limestone deposits of Cuddapah ages one on the right bank of the Talperu river east of Cherla ($18^{\circ}05' : 80^{\circ}50'$), and the other on the left bank of the river E.S.E. of Bhumanlanka ($18^{\circ}20' : 80^{\circ}30'$).

Deposit on the right bank of the Talperu river

Outcrops of the limestone are present for about 500 m. in a N.N.E.—S.S.W. direction to the north of Bhumanlanka. The maximum width of the limestone exposure is 63 metres. The general strike of the limestone bands varies from N. N. E.—S. S. W. to N. E.—S. W. and the dip is 40° — 70° to the E. S. E. or south-east. The limestone is compact, fine-grained and massive. Laterally the limestone grades into shaly or siliceous types. The limestone is used for lime manufacture for local use. The area to the east of the deposit and west of the Talperu river is covered by alluvium.

Deposit on the left bank of the Talperu river

The limestone deposit on the left of the river shows a general east-west strike and a dip of about 70° — 80° to the north or south. The limestone here is mostly siliceous or shaly. Another small limestone band is seen to the south of the deposit.

Area.	CaO %	SiO ₂ %	MgO %	R ₂ O ₃		No. of samples analysed		Area of outcrop.	Reserves in outcrop area.
				Al ₂ O ₃ %	Fe ₂ O ₃ %	Total No.	With CaO over 45%		
<i>Koilkuntla limestone—</i>									
Proddatur taluk—Katikepalle, Nilapuram and Peddasetti- palle.	40.69	22.00	0.28	1.97	..	3	1	....	....
Kamalapuram sub-taluk Erragudiapadu.	39.59	24.14	0.24	2.35	..	1	..	....	....
<i>Narji calcareous flags—</i>									
Jammalamadugu taluk—Purva- sungamanchipalle, Sale- variuppakapadu and Veperala.	45.32	13.74	0.34	3.42	..	3	2	21 sq. km.	283 million tonnes
Proddatur taluk—Gopayapalle	35.10	30.90	1.19	2.80	..	1	1	....	....
Kamalapuram sub-taluk Niduvuvvi.	46.11	13.19	0.72	1.40	..	1	1	....	40 million tonnes
<i>Narji grey massive limestones—</i>									
Jammalamadugu taluk—Ponna- thota and Talamanchipatnam area.	47.72	10.45	0.53	1.95	..	7	7	Over 90 sq. km.	2,680 million tonnes
Proddatur taluk Vellala	46.45	13.48	0.79	1.00	..	1	1	Over 5 sq. km.	....
Kamalapuram sub-taluk— Koduru and Niduvuvvi.	45.33	13.07	0.60	1.58	..	2	1	Over 23 sq. km.	634 million tonnes

Quality of the limestone :—Sixty one groove samples were collected from the deposit on the right bank of the Talperu river. Sixteen groove samples were collected from the deposit on the left bank of the Talperu river. Thirty-three samples showed less than 10 per cent silica and 28 samples showed silica varying between 10 and 30 per cent. The magnesia content is low, being less than two per cent in 59 samples. The R_2O_3 content is less than five per cent in 57 samples. All the other samples on the left bank are highly siliceous.

Reserves :—For the deposit on the right bank, reserves are estimated at 400,000 tonnes. Of this, 200,000 tonnes will be of cement grade and 200,000 tonnes of flux grade.

Out of 61 analyses, 30 showed insolubles at less than five per cent. The range in chemical composition of these 30 analyses is as follows :—

SiO ₂	R ₂ O ₃	CaO	MgO	Loss on ignition
1.94—4.75%	1.20—7.44%	49.70—52.32%	Trace — 2.11%	34.56—41.56%

The limestones on the left bank of the Talperu river are high in insolubles. These limestones are low in magnesia. If these limestones can be upgraded by beneficiation they can be used for the manufacture of cement.

Krishnan (1951) recorded exposures of intertrappean limestones from Kateru (17°02' : 81°47') to Kuntamuru (17°03' : 81°48') over a distance of 3.2 km. Limestones dip at low angles (5°—8°) towards the south or S. S. E. under an overburden which is 4.57 to 6 m. thick. The limestone band is 1.3 to 1.8 m. thick (average thickness 1.5 m.) and is of good quality (low in magnesia). About 760, 000 tonnes have been worked from this area.

Krishnan (1955) also recorded sporadic occurrences of *kankar* nodules near Jagampeta (17°10' : 82°04'). The quantity is small and not important except for making lime on a small scale.

According to C. Ramaswamy (Krishnan, 1953b) Intertrappean limestones is quarried in small quantities near Pata Nayakkanpalle (17°07' : 82°02') for lime burning.

Fairly large deposits of limestone of probable Cuddapah age, have been recorded by S. Krishnaswamy (Krishnan, 1951) near Bhumanlanka (18°20' : 80°30') and Sudibaka (18°20' : 80°30') both lying in Nugur taluk. This can possibly be used for cement manufacture after suitable beneficiation.

Large deposits of high grade *kankar*, are found near the village of Meduvayi (17°41' : 80°55') in the Bhadrachalam taluk. These are now being utilised for lime burning and may, according to S. Krishnaswamy, possibly be used for cement manufacture.

C. Ramaswamy (Krishnan, 1958) found near Albaka (18°12' : 80°40'), a band of limestone about 245 m. in length and about four metres in width.

C. Ramaswamy (Roy, 1962) examined the occurrence of *kankar* at Meduvayi (17°41' : 80°55') near Bhadrachalam. Here, *kankar* occurs over an area of about 12.9 hectares and within a depth of 3.7--4.0 m. from the surface. The total estimated reserves of the material is about 300,000 tonnes.

Guntur District

S. N. Sen (West, 1950) examined occurrences of limestone about five kilometres E.N.E. of Mugachintalapalem ($16^{\circ}01' : 79^{\circ}42'$). These bands with a total width of about 200 m. run for 800 m. Another important outcrop of limestone was noted north of Mannepalke Konda ($16^{\circ}08'$) about 10 km. north-west of Ballapalle ($16^{\circ}11' : 79^{\circ}41'$). Here the bands run for about one kilometre and the total width of the outcrop is about 500 m. The bands on the eastern portion are siliceous.

Bands of limestone and calcareous phyllite are noted west of Moddala Konda at about two kilometres east of Kanamalacheruvu. They run for about a kilometre. The bands approaching Moddala Konda are siliceous. About seven kilometres north-west of Kanamalacheruvu, another set of limestone outcrops are noted north and west of Kandurla Konda ($16^{\circ}138'$). Here the bands occur at irregular intervals and are also intruded by quartz-veins.

Chandrasekharia (West, 1951) reported that the Narji limestones lying to the north of Waumyconda range are eminently suited for the manufacture of Portland cement. These have been worked by A.C.C. and by the Andhra Cement Company Ltd.

M. Srirama Rao (West, 1951) carried out a detailed investigation on the limestones around Pidugurala ($16^{\circ}29' : 79^{\circ}53'$) and Nadikude ($16^{\circ}36' : 79^{\circ}43'$) in the Palnad taluk. The limestone bands are well exposed in the plains. They have a regional strike of E.N.E.—W.S.W. veering in places to N.E.—S.W. The dips are to the S.S.E. and south-east varying from as low as 5° to nearly 30° . The limestone is massive and exhibits wide variation in colour. Thin veins and stringers of calcite and quartz traverse the limestone at places. Limestone is well-exposed in the Pidugurala area at Sitarampuram where it is quarried by the A.C.C. Ltd., and at Nadikude where it is worked by the Andhra Cement Co. Ltd. The limestone, except for a cover of soil of about 1.5 m. in places, extends to not less than six metres in depth.

T. Madhusudhana Rao (Roy, 1961) has demarcated two limestone bands in the Macherla sub-taluk suitable for the manufacture of cement. One is west of Gangulagunta ($16^{\circ}19' : 79^{\circ}18'$) and Gottipalle ($16^{\circ}20' : 79^{\circ}18'$) with estimated reserves of 77.5 million tonnes and the other at Kandlagunta ($16^{\circ}23' : 79^{\circ}18'$) with a reserve of 47 million tonnes. The average of 24 analyses of limestone samples shows 16.32 per cent SiO_2 , 3.77 per cent Al_2O_3 and Iron oxide, 76.95 per cent CaCO_3 and 1.26 per cent MgCO_3 .

Kankar is widely distributed in the Guntur district, specially at Mangalagiri ($16^{\circ}26' : 83^{\circ}34'$), Chebrolu ($16^{\circ}12' : 80^{\circ}02'$), Nagondla and Venkayalagadu ($15^{\circ}55' : 80^{\circ}13'$), Lalupuram ($18^{\circ}16' : 80^{\circ}25'$), Peddakari ($16^{\circ}21' : 80^{\circ}30'$), Nekallu ($16^{\circ}30' : 80^{\circ}27'$) Sripuram ($16^{\circ}24' : 80^{\circ}18'$) and Peddakkupadu ($16^{\circ}28' : 80^{\circ}16'$). They are mostly used for lime manufacture.

Krishna District

Mohd. Ziauddin (Krishnan, 1958) examined the limestone beds near Jaggayyapeta ($16^{\circ}58' : 80^{\circ}04'$), and found the beds to be extending over a distance of about eight kilometres with an average width of about 600 m. and a thickness of nearly 12 m. The limestone is suitable for cement manufacture. The reserves have been estimated at about 275 million tonnes.

Of 31 analyses, 17 had SiO_2 between 5 and 10 per cent. The range in composition of these 17 analyses are given below :—

SiO_2	R_2O_3	CaO	MgO	Loss
5.88—9.92%	1.40—2.10%	48.45—50.83%	0.36—1.08%	38.70—40.06%

A large spread of compact, grey and white limestones is present near Muktyala dipping eastwards at angles varying from 10° to 20° . The thickness of the bands ranges from 24 to 30 m.

Karimnagar District

Limestone bands in the Sullavai series in the Narella ($18^\circ 55' : 79^\circ 02'$) area in the Karimnagar district were prospected by Hamzah Ali (Krishnan, 1958). They occur within a syncline extending from 800 m. S.S.W. of Kamalapur ($18^\circ 55' : 79^\circ 05'$) to near about Ganeshpalli ($18^\circ 58' : 78^\circ 58'$), over a distance of about 14 km. The extent of the deposit is about 15 sq. km. Analyses of eight representative samples of the rock have the range of CaCO_3 content from 78.2 to 91.4 per cent and MgCO_3 from 0.17 to 1.51 per cent. Two samples of calcareous shales showed CaCO_3 content at 56.86 and 55 per cent and MgCO_3 at 0.67 and 2.02 per cent, respectively (*Hyd. Geol. Surv. Jour.*, IV, Pt. 2, pp. 67-72). The limestones are suitable for cement manufacture.

Kankar derived from the decomposition of lime feldspars and calcic amphiboles of granites, basic rocks and dolerite dykes, has been noted by Hamzah Ali (Roy, 1961) to occur below the soil at various places. The *kankar* layer has a thickness from 30 cm. to 1 m. or even more. The material is locally burnt for lime.

Khammam District

A. S. Narasimhan (Roy 1961) investigated the limestone and marble deposits in the Yellandlapad area.

The areas investigated are (i) Manditog ($17^\circ 38' : 80^\circ 20'$), (ii) Nizampet ($17^\circ 34' : 80^\circ 16'$), (iii) Jestaipalle ($17^\circ 24' : 80^\circ 16'$), and (iv) Bethumpudi ($17^\circ 34' : 80^\circ 27'$).

The Manditog marble band extends over a length of 20 km. *via* Puba ($17^\circ 37' : 80^\circ 24'$) and Dandagundal ($17^\circ 37' : 80^\circ 25'$) to the south of Takalagudem ($17^\circ 33' : 80^\circ 21'$). The marbles of the region are medium to coarse-grained in texture and fairly interlocked. They are well-bedded and dip easterly at about 55° to 65° . The average overburden is estimated to be about two metres. The occurrences at Pubali, Dandagundal and to the S.S.E. of Takalagudem are similar to the Nanditog deposit. The total reserves down to a workable depth of 9.1 m. are estimated to be of the order of 138 million tonnes, out of which allowing for about one-third wastage, the available reserves will be of the order of about 91.5 million tonnes.

The marble deposits to the west of Jestaipalle consist of white and bluish grey varieties. These are very fine-grained in texture wherein the grains are uniform and show good interlocking. The reserves of marble in this area over a length of 244 m. are estimated at 368,000 tonnes. Allowing about one-third for wastage, the reserves work out to about 245,000 tonnes.

The marbles of the Manditog and Jestaipalle area contain tremolite, but bands containing this mineral could be separated out. The marbles are fit for use for structural purposes like slabs, panels, facings and blocks, but they lack the fineness of the grains, the uniformity of the texture, and such a degree of close interlocking of the grains as to be fit for being used as statuary marble. Moreover the very limited colour choice presented by these marbles makes them unsuitable for use in decorative and statuary purposes.

The limestone of the Nizampet and Bethumpudi areas are thinly jointed and lack the requisite crystalline nature. Thus although the deposits are enormous they are unsuitable even for the quarrying of dimension stones.

The MgO content of the limestones from the above localities varies from 5 to 19 per cent. Thus these limestones are not suitable for the manufacture of cement, or for use in sugar and paper industries.

P. V. Rao and Narasimhan (Roy, 1961) recorded the occurrence of a large limestone band 1.6 km. in width, east of Tummaschilka ($17^{\circ}37'$: $80^{\circ}28'$) and another smaller and impure one interbanded with phyllite and slate of the Pakhal series, W.S.W. of Gattumalla ($17^{\circ}38'$: $80^{\circ}38'$). A sample of limestone from each of the above localities gave on analysis, 54.49 per cent CaCO_3 and 6.7 per cent MgCO_3 , 38.52 per cent CaCO_3 and 4.19 per cent MgCO_3 , respectively. Two veins of white to yellowish impure calcite, occur associated with hornblende-gneiss in the Kottagudem ($17^{\circ}33'$: $80^{\circ}37'$) region. One of them lies south of the Yellandu-Kottagudem road at mile 16/4 and the other about 600 m. south of the same road at mile 17/2. The veins range in thickness from 90 cm. to 1.8 m. and in length from 9.1 to 30.5 m. A sample of impure calcite from the second locality, on analysis, showed 74.96 per cent CaCO_3 and 0.02 per cent MgCO_3 .

P.V. Rao and Narasimhan reported that in the vicinity of the hornblende-gneiss in the Kottagudem area, *kankar* is found scattered in the soil. Some of the deposits as the one about 1.5 km. south-east Ramavaram ($17^{\circ}31'$: $80^{\circ}37'$) are 90 cm. to 1.2 m. in thickness and are locally burnt for lime. Rao recorded that in the junction zone between the Gondwana rocks and the Pakhals along the western margin of the Yellandu coalfield, specially in the region between Polampallu Pit ($17^{\circ}35'$: $80^{\circ}18'$) and Pusarpalli ($17^{\circ}37'$: $80^{\circ}18'$) *kankar* is found in large quantities. It is however much mixed with soil and is worked locally for burning lime on a small scale.

Kurnool District

N. V. B. S. Dutt (West, 1951) recorded the occurrence of calcareous tufa of good quality at Palkur ($15^{\circ}25'$: $78^{\circ}15'$), Nandavaram ($15^{\circ}22'$: $78^{\circ}17'$) and other places in the Narji (Nirji) limestone and the Auk (Avuku) shale. It is quarried and burnt for lime. Earthly calcareous tufa is being used as road metal. According to Krishnan (1951), the exposure of soft chalk just south and south-east of Palkur occupies an area of 1 km. by 600 m. to a depth of 3 to 3.6 m. below the mantle of soil. A minimum of two million tonnes of chalk is estimated in this deposit, with double this quantity as probable reserves. Near Nandavaram, there are 3 or 4 exposures of chalk. The first band, 400 m. N.N.W. of the village measures 320 m. by 183 m., shows a 1.5 m. layer of chalk capped by a thin bed of calcareous tufa. The second exposure, located 200 m. north of the village occupies an area

137 m. $\times$ 36 m., and contains a chalk bed at least 1.2 m. thick. The third exposure on the western outskirts of the village is about 90 m. $\times$ 90 m. in area and 90 cm. thick. The fourth, 400 m. north-west of Nandavaram, is exposed in an area of 457 m. by 274 m., and is apparently more than two metres thick. The available reserves of these deposits are 160,000 tonnes, 8,000 tonnes, 27,500 tonnes and 410,000 tonnes respectively. The analyses of representative samples from these deposits are as follows :—

	SiO ₂	R ₂ O ₃	CaO	MgO
Palkur . . .	3.05%	0.50%	52.25%	1.63%
Nandavaram .	2.77%	1.7%	52.08%	0.48%

Large quantities of *kankar* have been formed over the slates of the Markapur-Cumbum belt, especially near Markapur and Pedda Obanayanipalle. It is apparently argillaceous, and may yield hydraulic lime on burning.

M. S. Venkatram and M. S. Balasundaram (1952) investigated the Vempalle limestone belt extending from the region east of Dhow and Veldurti (15°33' : 77°56') to 20 km. north-east of Kurnool (15°50' : 78°03'). At the north-east end it is covered by the younger formations. Out of 14 analyses, four showed insolubles less than 10 per cent. The range in chemical composition of these four samples is given below :—

SiO ₂ or in-solubles.	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO
2.39—9.39%	0.35—1.20%	0.90—2.02%	4.42—21.16%	26.25—47.53%

Large deposits of calcareous tufa also occur near Bugganapalle (15°23' : 77°53') and Periked (15°23' : 77°52'). The Bugganapalle occurrence occupies an area of 400 m. by 200 m. Both the deposits show a southward dip of 25°. A small portion of this deposit, 45.7 m. $\times$ 27.4 m. $\times$ 3 m. close to the village, is of high grade. The range in chemical composition of the *kankar* is as follows:—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO
0.02—2.28%	0.30—1.32%	0.50—1.80%	0.36—1.01%	52.01—54.74%

Chalk occurs at one kilometre N.N.E. of Chinna Malkapuram (15°22' : 77°59'). According to R. Thiagarajan (1946-47) it can be used in the manufacture of putty, as rubber fillers and as glazes for ceramic ware. A big exposure of chalk occurs 2.5 km. E.S.E. of Kochecheruvu (15°19' : 77°52'). The extent of the occurrence is 61 by 45 metres.

An analysis of a sample of chalk is given below :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Loss
7.36%	6.12%	1.48%	24.58%	20.80%	39.18%

Chalk varying in width between 1.2 and 4.6 m. occurs 1.2 km. south-west of Malkapuram (15°21' : 77°59'). The country rock is the Vempalle limestone, dipping at 20°—25° southwards. The width varies between 1.2 and 4.6 m. An analysis of chalk from this locality gives the following results :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO
60.41%	4.98%	0.62%	—	2.25%	25.07%

The material is highly refractory and was used in the ceramic factory.

During 1945, Balasundaram examined the occurrences of grey calcareous flagstones near Kurnool ($15^{\circ}50' : 78^{\circ}03'$). The outcrops of grey calcareous flags extend from Dandanapuram ($15^{\circ}51' : 78^{\circ}01'$) through Kurnool town to the bank of the Hindri river. The flags dip at low angles of 3° to 7° towards the east or south-east. Slabs 2.5 to 7.5 cm. in thickness are used as pavement flags, and the material yielding massive slabs is used for lime burning. The analyses show that SiO_2 is as high as 27.5 per cent and Al_2O_3 and MgO are low.

V. Venkatesh (West, 1949) reported extensive occurrences of limestones, suitable for building purposes, near Bujanuru ($15^{\circ}40' : 78^{\circ}26'$), Chindukuru ($15^{\circ}38' : 78^{\circ}27'$), Pulimaddi ($15^{\circ}33' : 78^{\circ}26'$), Bilakala Guduru ($15^{\circ}41' : 78^{\circ}27'$) and Gora Kallu ($15^{\circ}34' : 78^{\circ}25'$). Large deposits of *kankar* suitable for lime burning have been reported around Bogeswaram ($15^{\circ}37' : 78^{\circ}27'$).

N. V. B. S. Dutt (Krishnan, 1953b) recorded small occurrences of calcareous tufa at the following places :—two kilometres east of Chagalamari ($14^{\circ}58' : 78^{\circ}36'$) ; 800 m. west of Ankalammapalle ($15^{\circ}13' : 78^{\circ}53'$), 1.6 km. W.N.W. of Sanjivaraopeta Rest House ($15^{\circ}17' : 78^{\circ}54'$), and 6.5 km. north of Diguvametta ($15^{\circ}24' : 78^{\circ}50'$). At some places the material is burnt for lime.

N. V. B. S. Dutt (1962) investigated the limestone deposits of the Kurnool system. The limestones of this system belong to Narji (Jammalamadugu series), Koilkuntla and Nandyal horizons. The chemical analyses of these limestones reveal that the grey massive Narji limestones and the adjacent layers of calcareous flags, and the greenish grey limestone band in the Nandyals are excellent for cement manufacture.

The details of the analyses and reserves are given below :—

According to N. V. B. S. Dutt (1962 b), the middle unit of the Koilkuntla imestone, exposed at Muttaluru ($15^{\circ}11' : 78^{\circ}35'$) Allagadda ($15^{\circ}08' : 78^{\circ}31'$) Jittapalli ($15^{\circ}07' : 78^{\circ}37'$), Krishnapuram ($15^{\circ}05' : 78^{\circ}35'$), Kottapalle ($15^{\circ}01' : 78^{\circ}37'$) and Rampalle ($15^{\circ}02' : 78^{\circ}32'$) and having an estimated thickness of the order of 30 m. in the west, 25 m. in the middle and 10 m. in the east, is of cement-grade.

The SiO_2 or insolubles range from 10.60 to 16.48 % and CaO from 43.84 to 47.27%.

Nellore District

A small patch of crystalline limestone was noticed at 200 m. east of Korivivandlapalle ($15^{\circ}26' : 79^{\circ}31'$). Foote (1880) mentioned a few occurrences of limestones in the following areas :—

A 1.5 m. thick band of saccharoidal limestone occurs south-west of Chundi. Fragments of pale grey and pink limestone have been noticed on the high ground five kilometres north-east of Pedda Alavalapadu. White to pale grey limestone is exposed east of Pedda Arikatla, 13 km. north-east of Kanigiri. Similar limestone is noticed south-west and east of Irsलगudem. Impure limestone occurs at Punnugodu, eight kilometres north-east of Kanigiri, the curved outcrop of which is 183 m. long and 2.4—3m. thick.

Area	CaO %	SiO ₂ %	MgO %	Al ₂ O ₃ %	Fe ₂ O ₃ %	No. of samples analysed		Area of outcrop sq. km.	Reserves in outcrop area million tonnes.
						Total No.	With CaO over 4.5%		
1	2	3	4	5	6	7	8		
<i>Limestone band in the Nandyals—</i>									
Sirvel <i>taluk</i> Erraguntla, Jillella, Mota-kalapalle at the Nandyal border and Peruru— Greenish grey and purple bands.	40.80	18.83	3.04	3.85	—	11	—	—	—
Greenish grey band only	42.06	15.24	3.63	2.01	11.72	5	—	—	—
<i>Koilkuntla limestone—</i>									
Banganapalle sub- <i>taluk</i> , Appalapuram, Cheruvupalle and Sankalapuram.	38.54	25.57	0.10	3.65	—	4	—	—	—
Koilkuntla <i>taluk</i> Joladarasi and Kolugotla	34.46	31.89	Trace	2.10	2.14	6	—	—	—
Sirvel <i>taluk</i> Southern part	34.67 to 47.27	10.6 to 30.64	Trace to 2.38	0.80 to 3.90	—	15	—	—	—
<i>Narji calcareous flags—</i>									
Koilkuntla <i>taluk</i> including Banganapalle enclaves—Between Owk (Avuku) and Bhogasamudram.	43.45	17.57	0.27	2.33	0.88	15	7	47 sq. km.	955 million tonnes.
<i>Narji grey massive limestone—</i>									
Dhone (Dronachalam) <i>taluk</i> Noreducherla	47.01	10.80	Trace	2.48	1.12	1	1	—	—
Koilkuntla <i>taluk</i> , including Banganapalle enclaves—Between Owk (Avuku) and Bhogasamudram.	47.31	11.32	"	2.27	0.77	18	17	130 sq. km.	4,775 million tonnes.
<i>Narji basal flaggy limestones—</i>									
Dhone <i>taluk</i> Boyinnacheruvupalle	34.91	30.63	Trace	4.41	2.42	2	—	—	—
<i>Koilkuntla limestone—</i>									
Kurnool <i>taluk</i> , Varakuru	40.7	28.63	0.45	0.45	1.05	6	1	—	—

Area	No. of samples analysed										Reserves in outcrop area
	1	2	3	4	5	6	7	8	9	10	
		CaO %	SiO ₂ %	MgO %	Al ₂ O ₃ %	Fe ₂ O ₃ %	Total No.	With CaO over 45%	Area of out-crop		
<i>Nandikotkur taluk</i> —											
Nagahalli and Nandikotkur		35.53	30.35	0.19	2.03	2.13	12	—	—	—	—
<i>Narji calcareous flags</i> —											
Kurnool taluk West of Hindri river . .		31.30	29.22	1.50	5.36	3.60	17	—	—	—	—
From the confluence of the Tungabhadra and Krishna to Ramalakota—											
Satanikota-Nandikotkur taluk		32.43	32.36	0.45	4.43	3.67	3	—	—	—	—
Uyyalavida-Kurnool taluk		41.73	21.43	0.43	—	1.86	2	1	—	—	—
Krishnapuram and Siddanagatta, Dhono taluk.		38.23	25.46	0.30	—	3.56	1	—	—	—	—
In Botamohota—Banganapalle area Botamohota, including a small part of Nandyal taluk near and 5 km. north-east of Bug-gaupallo R. S.—Dhone taluk.		40.60	—	22.05	0.91	2.72	10	—	—	—	—
<i>Narji dark grey and whitish, ash grey or light coloured massive limestones</i> —											
1. West of Hindri river { Kurnool taluk { (a) (b) (c)		43.96	15.85	0.88	—	2.44	5	1	More than 8 sq. km.	More than 200 million tonnes.	
		40.12	14.59	0.11	—	2.30	3	2			
		47.06	11.8	1.24	—	2.60	5	3			
From the confluence of the Tungabhadra and Krishna to Ramalakota.		43.9	17.91	Trace	—	2.51	7	2	30 sq. km.	782 million tonnes.	
Satanikota to Brahmanakotkur, Nandikotkur taluk.		43.65	17.14	0.53	—	2.60	1	—	—	—	
Gadidemandige (Gargayapuram to Uyyalavida, Kurnool taluk.		44.72	16.65	0.20	—	2.79	3	2	38.8 sq. km.	1,066 million tonnes.	

Krishnapuram, Dhone <i>latuk</i>	45-14	15-77	0-21	—	2-41	2	2	1-0 sq. km.	50-million tonnes.
Ridge west of Somayajulapalle, Kurnool <i>latuk</i> —									
(a)	48-31	10-62	Trace	—	1-50	1	1	—	—
(b)	44-02	17-54	0-22	—	1-05	1	—	—	—
In Batamohoria—Baiganapalle area	47-24	31-84	0-61	—	1-09	19	18	—	—
Batamohoria including the Nandyal portion, Dhone <i>latuk</i> .	40-22	14-16	0-57	—	2-44	58	47	18 sq. km.	432 million tonnes.
Yannakondla—Baiganapalle-sub- <i>latuk</i>	40-24	10-24	0-18	—	4-10	1	1	24-6 sq. km.	670 million tonnes.
<i>Naoji purple and greenish grey massive limestone—</i>									
West of Hindri Elvor	40-0	12-05	Trace	—	2-10	1	—	—	—
Ranalkota (Dhone <i>latuk</i>)	34-80	30-50	0-41	—	3-50	1	—	—	—
Batamohoria—purple	40-04	22-50	0-78	—	2-55	12	1	—	—
Greenish grey	30-80	27-46	1-16	—	3-29	34	1	—	—

Small bands of crystalline limestone, occur near the Kavali—Udaygiri and Bundakindipalli.

According to V. Subramanyam (Krishnan 1953), bedded white limestone occurs near Anamasamudram ($14^{\circ}41' : 79^{\circ}41'$). The limestone bands are vertical with N. N. E.—S. S. W. strike and have a thickness of nine metres.

C. Kannan (Roy, 1964) has traced a fairly persistent narrow zone of crystalline limestone intercalated with impure limestone over a strike length of nearly four kilometres within the Dharwar schists west and south of Uttukuru ($14^{\circ}52' : 79^{\circ}32'$), in the Garimanipenta copper belt. Good quality limestone extends as impersistent bands 1.5 to 3.0 m. in width. The aggregate width of the bands is about 15 m. in the zone.

According to Krishnan (1961), *kankar* is fairly widespread in this district. Some of the occurrences are near Darsi ($15^{\circ}47' : 79^{\circ}41'$), Battuvaripalli ($15^{\circ}38' : 79^{\circ}33'$), Nandipalem ($15^{\circ}36' : 79^{\circ}35'$), Talamella ($15^{\circ}36' : 79^{\circ}44'$) and Edavalli ($15^{\circ}28' : 79^{\circ}33'$). Tufaceous material forms a thin bed in the basin of the Upputeru river. It is quarried and dressed into blocks for building purposes at Janakammapeta ($15^{\circ}01' : 79^{\circ}51'$), Peddaparavi ($15^{\circ}01' : 79^{\circ}49'$), Mutyalapad ($15^{\circ}00' : 79^{\circ}49'$), Kommi ($14^{\circ}58' : 79^{\circ}46'$) and Adimurtipuram ($14^{\circ}58' : 79^{\circ}41'$).

According to Foote (1880) a bed of massive *kankar* is found three kilometres west by north of Pamur near the embankment of the Dupugutla tank. A similar formation is seen in the waste channel of the Kanigiri tank, extending westwards. Another important occurrence is seen along the brow of the high ground south of the Paleru valley five kilometres north of Kandukur. It forms a large sheet near Konda Kandukur. A dense and fairly massive deposit of *kankar* is also seen at Kovur.

According to B. C. Roy (Krishnan, 1955) beds of marine shells occur along the borders of the Pulicat Lake near Mizuru ($11^{\circ}46' : 80^{\circ}05'$), Atakanitippa ($13^{\circ}43' : 80^{\circ}08'$), Venadu ($13^{\circ}38' : 80^{\circ}08'$), Tada ($13^{\circ}36' : 80^{\circ}02'$), Irkam ($13^{\circ}34' : 80^{\circ}09'$) and Sulurpeta ($13^{\circ}42' : 80^{\circ}01'$). These beds vary from 30 to 45 cm. in thickness and occur within 1.2 m. from the surface. Though the distribution is irregular, every 2.5 sq. km. of shell bearing area contains about one million tonnes of shells. The area occupied by the beds may be about five sq. km.

Visakhapatnam District

According to Krishnan (1951) limestones occur near Nilgalagunta having a thickness of about 27.5 m. Argillaceous limestones occur near Araguda and Gupteswar.

K. Ranganathan (Krishnan, 1958) recorded the occurrence of a crystalline limestone band about 1.5 km. long and 4.5 m. wide east of Katuki ($18^{\circ}17' : 83^{\circ}01'$) and another with a width of about 100 m. near Mandlavalasa ($18^{\circ}23' : 83^{\circ}00'$).

K. Ranganathan (Roy, 1955) investigated the crystalline limestone deposits near Borra ($18^{\circ}17' : 83^{\circ}03'$) and Kothiguda ($18^{\circ}17' : 83^{\circ}02'$). These deposits are located about 86 km. from Visakhapatnam close to the road leading to Jeypore. They are also close to the Kottavalasa—Bailadila railway, now under construction.

The deposit at Borra is about 1,100 m. long with a maximum width of about 275 m. The limestone is generally massive and medium-grained.

The outcrop area is about 232,500 sq. m. A reserve of three million tonnes is estimated for the first six metre depth.

The range in chemical composition of 14 samples analysed is as follows :—

SiO ₂	R ₂ O ₃	CaO	MgO	Loss
1.36—9.75%	0.30—2.20%	41.32—49.95%	3.62—10.85%	40.38—43.28%

The southern and northern parts of the area contain better quality limestone than the central part. The percentage of magnesia ranges from 3.62 to 10.85. In general the silica percentage is less than 3; other impurities in the form of iron oxide and alumina are less than 2%. Though crystals of apatite are found in the limestone, the average P₂O₅ percentage is negligible. South-west of Kothiguda (18°17' : 83°02'), about 1.5 km. west of Borra, another limestone band about 1.5 km. long and 45 m. wide runs in an approximate east-west direction. The quality of this limestone band is similar to that of the one above.

N. V. B. S. Dutt (Roy, 1962b) demarcated in the Borra area 24 bands of marble, of which eight bands are over 300 m. long. He estimates the reserves at 7.7 million tonnes. The coarse-grained marble may be used as a filler, while the fine-grained marble is suitable for use in iron and steel industry.

Ranganathan (Roy, 1955) also recorded thin bands of limestone near Danselivalasa (18°11' : 82°56'), Kotturu (18°13' : 83°05'), Gangavaram (18°13' : 83°06'), Tylda (18°13' : 83°03') and Gunma (18°10' : 83°02'). These are only of academic interest.

According to S. V. Srikantia (1958) the analyses of *kankar* from Tallavalasa are as follows :—

CaO	MgO	Fe ₂ O ₃	Al ₂ O ₃	SiO ₂	P ₂ O ₅	CO ₂
%	%	%	%	%	%	%
47.43	3.34	1.60	2.12	4.51	0.02	40.98
52.92	0.43	0.78	1.72	2.13	0.04	41.98

West Godavari District

Krishnan (1955) investigated in 1946 the Intertrappean limestone deposits of the Kovvur area. The limestone occurs as a bed amidst the Deccan Trap dipping at an angle 4° to 7° towards the south. To the west of the Godavari river, the bed can be traced from west of Pangadi (17°01' : 81°39') to the south-west of Devarapalle (17°02' : 81°33') over a length of nearly 6.5 km. They are about 6 to 8 m. thick in the middle but thin down at the eastern and western ends. The total reserves of limestone in the Kovvur area are of the order of 3.4 million tonnes, out of which 1.7 million tonnes are of cement grade.

Out of 83 samples of limestones analysed, 45 had SiO₂ less than 5%. The range in composition of these 48 analyses is as follows :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
1.38—4.26%	0.48—1.88%	1.66—3.22%	36.91—52.50%	1.23—14.01%

Twenty five samples had SiO_2 between 5 and 10 per cent and the rest had SiO_2 above 10 per cent. The range in composition of the 25 analyses is as follows :—

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
5.36—9.72%	0.58—3.47%	1.21—4.03%	35.67—49.12%	1.48—2.86%

Srikakulam District

According to S. V. Srikantia (1958), the analyses of *kankar* samples from the different localities are as follows :—

Locality	CaO %	MgO %	Fe_2O_3 %	Al_2O_3 %	SiO_2 %	P_2O_5 %	CO_2 %
Regatl village . . .	52.08	0.74	1.00	1.64	6.55	0.01	41.12
Geddapuvalasa . . .	49.48	1.86	1.83	3.49	4.59	—	—
Tatiguda . . .	49.66	0.61	2.40	2.23	5.49	0.04	39.6
Venkatapuram . . .	37.39	10.46	2.53	1.27	7.6	—	—
Musidivalasa . . .	51.35	0.61	1.06	0.04	5.43	—	—
Meesalapota . . .	51.72	0.37	1.06	0.87	4.82	—	—
Hadapapeta . . .	46.87	0.80	2.13	2.98	8.11	0.03	39.3
Devinkannapaka . . .	36.08	1.21	1.46	1.91	28.55	—	—
Sigedam . . .	49.66	0.70	0.93	1.9	7.75	—	—
Reddipeta . . .	43.85	0.90	2.26	5.57	11.43	0.04	35.49
Ravivalasa . . .	43.68	1.86	1.73	3.38	11.66	0.02	35.49
Laximipuram . . .	43.63	3.26	1.73	3.38	12.16	0.02	38.82

REFERENCES

- Balasundaram, M.S., 1946.—Limestone (calcareous flags) near Kurnool town, Madras G.O. 980, dated 6-3-46.
- , 1946—Report on Vempalle limestone belt (Anantpur and Kurnool), Madras G.O. No. 2149, dated 1-6-1946.
- Dutt, N.V.B.S., 1962.—Geology of the Kurnool system of rocks in Cuddapah and the southern part of Kurnool district. *Rec. Geol. Surv. Ind.*, Vol. 87, Pt. 3, pp. 549-604.
- , 1962b.—Chemical composition of certain limestone formations of Madhya Pradesh and Andhra Pradesh. *Indian Minerals*, Vol. 16, No. 4 pp. 367-379.
- Foote, R. B., 1880.—Geological structure of the Eastern coast. *Mem. Geol. Surv. Ind.* Vol. 16, Pt. 1.
- Krishnan, M.S., 1951.—Mineral Resources of Madras. *Mem. Geol. Surv. Ind.*, Vol. 80, pp. 174-182.
- , 1953.—General Report for 1940, 41 and 42. *Rec. Geol. Surv. Ind.*, Vol. 79, Pt. 1, p. 73.
- , 1953b.—General Report for 1950. *Rec. Geol. Surv. Ind.*, Vol. 84, Pt. 1, p. 89.
- , 1954.—General Report for 1951. *Rec. Geol. Surv. Ind.*, Vol. 85, Pt. 1, pp. 45, 66, 72.

REFERENCES—*contd.*

- Krishnan, M.S., 1954b.—General Report for 1952. *Rec. Geol. Surv. Ind.*, Vol. 86, Pt. 1, pp. 107, 108.
- , 1955.—General Report for 1943, 44, 45 and 46. *Rec. Geol. Surv. Ind.*, Vol. 79, Pt. 2, p. 669, 671.
- , 1958.—General Report for 1953. *Rec. Geol. Surv. Ind.*, Vol. 87, Pt. 1, pp. 111, 113.
- , 1958b.—General Report for 1954. *Rec. Geol. Surv. Ind.*, Vol. 88, Pt. 1, pp. 118, 121.
- Roy, B. C., 1961.—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, Pt. 1, p. 115, 117, 122.
- , 1962.—General Report for 1956. *Rec. Geol. Surv. Ind.*, Vol. 91, Pt. 1, p. 76.
- , 1962b.—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, Pt. 1, p. 45.
- , 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.*, Vol. 95, Pt. 1.
- Srikantia, S. V., 1958.—Kankars, *Indian Mining Journal*, 1958.
- Subramanyam, V. and Son, S. N. 1944-45.—Limestone near Cherla, East Godavari district, Progress Report for 1944-45. Unpublished.
- Thiagarajan, R., 1946-47.—Progress Report : Chalk deposits in Kurnool. Unpublished Report, G.S.I.
- Venkatram, M. S. and Balasundaram, M. S., 1953.—Geology of the Vempalle Limestone Belt. *Rec. Geol. Surv. Ind.*, Vol. 78, Pt. 4, pp. 419-480.
- West, W. D., 1949.—General Report for 1947. *Rec. Geol. Surv. Ind.*, Vol. 81, Pt. 1, p. 54.
- , 1950.—General Report for 1948. *Rec. Geol. Surv. Ind.*, Vol. 82, Pt. 1, pp. 58, 59.
- , 1951.—General Report for 1949. *Rec. Geol. Surv. Ind.*, Vol. 83, Pt. 1, pp. 94, 142, 144.

LOCALITY INDEX

Adilabad district :

Latitude : Longitude

Bhimsari	19°42' : 78°32'
Gondipet	19°03' : 79°27'

Anantapur district :

Chilavaripalle	14°38' : 77°54'
Daditola	14°56' : 77°58'
Kamalapuram	14°53' : 77°32'
Kona Uppalapadu	15°06' : 77°54'
Murikinillapalli	14°50' : 77°30'
Mutssukota	14°51' : 77°53'
Pamidi R. S.	14°58' : 77°34'
Rayalacheruvu	15°03' : 77°49'

Cuddapah district :

Erragudipadu	14°37' : 78°37'
Gopayapalle	14°57' : 78°33'
Guvvalacheruvu	14°18' : 78°45'
Katikepalle	14°49' : 78°42'
Koduru	14°38' : 78°32'
Nandimandalam	14°24' : 78°32'
Niduzuvvi	14°39' : 78°30'
Nilapuram	14°53' : 78°41'
Peddasettipalle	14°46' : 78°31'
Ponnatota	14°50' : 78°22'
Pulivendla	14°25' : 76°14'
Purvasungaman chipalle	14°47' : 78°27'
Salevariuppala padu	14°54' : 78°24'
Talamanchipatnam	14°57' : 78°19'
Vellala	14°58' : 78°32'
Vempalle	14°22' : 78°28'
Veparala	14°51' : 78°21'

*East Godavari district :**Latitude : Longitude*

Albaka	18°12' : 80°40'
Bhumanlanka	18°20' : 80°30'
Cherla	18°05' : 80°50'
Jaggampeta	17°10' : 82°04'
Kateru	17°02' : 81°47'
Kuntamuru	17°03' : 81°48'
Meduvayi	17°04' : 80°16'
Pata Nayakkanpalle	17°07' : 82°02'
Sudibaka	18°20' : 80°30'

Guntur district :

Ballapalle	16°11' : 79°41'
Budavada	15°51' : 80°09'
Chebrolu	16°12' : 80°02'
Gangulagunta	16°19' : 79°18'
Gottipalle	16°20' : 79°18'
Kanamalacheruvu	16°05' : 79°30'
Kandlagunta	16°23' : 79°18'
Lalupuram	18°16' : 80°25'
Mangalagiri	16°26' : 80°34'
Mugachintalapalem	16°01' : 79°42'
Nadikude	16°36' : 79°43'
Peddakari	16°21' : 80°30'
Peddakkupadu	16°28' : 80°16'
Pidugurala	16°29' : 79°53'
Pratipedu	16°16' : 80°20'
Sripuram	16°24' : 80°18'

Krishna district :

Jaggayyapeta	16°58' : 80°04'
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Karimnagar district :

Ganeshpalli	18°58' : 78°58'
Kamalpur	18°55' : 79°05'
Narella	18°55' : 79°02'

*Khammameth district :**Latitude : Longitude*

Bethumpudi	17°34' : 80°27'
Dandagundal	17°57' : 80°25'
Gattumalla	17°38' : 80°38'
Jestaipalle	17°24' : 80°16'
Kothagudium	17°33' : 80°37'
Manditog	17°38' : 80°20'
Nizampet	17°34' : 80°16'
Polampalli Pit	17°35' : 80°18'
Pubali	17°37' : 80°23'
Pusapalli	17°37' : 80°18'
Ramavaram	17°31' : 80°37'
Takalagudem	17°33' : 80°21'
Tummaschilka	17°37' : 80°28'

Kurnool district :

Allagadda	15°08' : 78°31'
Ankalammappalle	15°13' : 78°53'
Appalapuram	15°20' : 78°19'
Banganapalle	15°22' : 78°13'
Betamcherla	15°27' : 78°09'
Bhogasamudram	15°01' : 78°01'
Bilakala Gudur	15°41' : 78°27'
Bogeswaram	15°37' : 78°27'
Boyinacheruvupalle	15°14' : 77°56'
Brahmanakottukuru	15°49' : 78°12'
Bugganipalle	15°29' : 78°12'
Bujanura	15°40' : 78°26'
Chagalamaru	14°58' : 78°36'
Cheruvupolle	15°24' : 78°16'
Chindukuru	15°38' : 78°27'
Dandanapuram	15°51' : 78°01'
Dhone	15°24' : 78°58'
Erraguntla	15°25' : 77°52'

	<i>Latitude-Longitude</i>
Gadidemadugu (Gargeyapuram)	15°47' : 78°09'
Gora Kalu	15°34' : 78°25'
Jillella	15°21' : 78°28'
Joladarasi	15°15' : 78°21'
Kalugotla	15°13' : 78°07'
Koccheruvu	15°19' : 77°52'
Kottapalle	15°01' : 78°37'
Krishnapuram	15°05' : 78°35'
Kurnool	15°50' : 78°03'
Malkapuram	15°21' : 77°59'
Markapur	15°40' : 79°15'
Mittapalle	15°07' : 78°37'
Motakalapalle	15°24' : 78°32'
Muttaluru	15°11' : 78°34'
Noreducherla	15°12' : 77°55'
Nandavaram	15°23' : 78°17'
Nandikotkur	15°52' : 78°18'
Nagaluti	15°48' : 78°15'
Owk (Ayuku)	14°30' : 79°40'
Palkur	15°25' : 78°15'
Pulimaddi	15°33' : 78°26'
Rampalle	15°02' : 78°32'
Sanjivaraopeta Rest House	15°17' : 78°54'
Sankalapuram	15°20' : 78°17'
Santanikota	15°55' : 78°13'
Siddanagatta	15°34' : 78°04'
Somayajulapalle	15°35' : 78°11'
Tabjula	14°54' : 77°49'
Uyyalavara	15°38' : 78°05'
Varakuru	15°41' : 78°11'
Veldurti	15°33' : 77°56'
Yannakondla	15°22' : 78°13'

Nellore district :**Latitude-Longitude**

Adimurtipuram	14°58' : 79°04'
Auamasamudram	14°41' : 79°41'
Atakanitippa	13°43' : 80°08'
Battavaripalle	15°38' : 79°33'
Chundi	15°10' : 79°40'
Darsi	15°47' : 79°41'
Edavalli	15°28' : 79°33'
Irkam	13°34' : 80°09'
Janakammapeta	15°01' : 79°51'
Kanigiri	15°15' : 79°25'
Kavali	14°55' : 79°55'
Kommi	14°58' : 79°46'
Korivivandalapalle	15°26' : 79°31'
Kovur	14°30' : 79°53'
Mijuru	14°46' : 80°05'
Mutyalapad	14°59' : 79°49'
Nandipalem	15°36' : 79°35'
Pamaru	15°00' : 79°20'
Pedda Alavalapadu	15°15' : 79°55'
Pedda Arikatla	15°30' : 79°30'
Peddaparavi	15°00' : 79°49'
Sulurpeta	13°42' : 80°01'
Tada	13°36' : 80°02'
Talamella	15°36' : 79°44'
Udayagiri	14°50' : 79°15'
Uttukuru	14°52' : 79°32'
Venadu	13°38' : 80°08'

Vishakhapatnam district :

Borra	18°17' : 83°03'
Dansolivalasa	18°11' : 82°58'
Gangavaram	18°13' : 83°06'

	<i>Latitude-Longitude</i>
Gunma	18°10' : 83°02'
Katuki	18°17' : 83°01'
Kotturu	18°13' : 83°05'
Mandlayalasa	18°23' : 83°00'
Tylda	18°13' : 83°03'
<i>West Godavari district :</i>	
Devarapalle	17°02' : 81°33'
Pangadi	17°01' : 81°39'

ASSAM

Crystalline limestone of Archaean age occurs in Abor Hills, Sadiya Frontier Tract, Miju Hills, Daphabhum and Mishmi Hills. The Cretaceous limestone deposit occurs in the Dihang river valley at Pasighat. Nummulitic limestones occur in Garo, Khasi, Jaintia and Mikir Hills.

Garó Hills District

A borehole sunk by S. N. Sen and M. M. Munshi (Roy, 1962), in the west Darangiri coalfield in the course of drilling for coal, struck a limestone band 13.4 m thick in the central portion of the basin. The limestone contains insolubles ranging from 5.12 to 18.08 per cent, R_2O_3 from 2.10 to 3.40 per cent, CaO from 41.58 to 50.04 per cent and MgO in trace.

Limestones varying in thickness from 15 to 90 metres are exposed on the southern side of the Tura range. At Dalmagiri the limestone is over 45 m. in thickness. Limestone also occurs in the Simsang Gorge near Siju Artheke ($25^{\circ}19' : 90^{\circ}41'$).

Khasi and Jaintia Hills District

Therriaghat ($25^{\circ}11' : 91^{\circ}45'$) : Several bands of massive limestone, totalling a thickness of over 300 m., occur on the left bank of the Sohryngkew and extend westwards to Shella. The individual limestone bands vary from 6 to 120 m. in thickness. The total area between Therriaghat and Shella covered by the nummulitic limestone is about 32 sq. km. Cement grade limestone occurs over an area of 11.5 sq. km. Taking the average thickness of limestone as 30 m., the reserves of cement grade limestone have been estimated at 1000 million tonnes in the Therriaghat-Shella region.

Shella ($25^{\circ}11' : 91^{\circ}38'$) : Six bands of limestone (Sylhet Stage) of varying thickness show an east-west trend, with a southerly dip ranging from 10° to 70° .

The reserves of the limestone bands occurring in the Khasi and Jaintia Hills district are described below :—

Basal Band : Assuming a thickness of 126 m. and a length of 6.4 km., the reserves of limestone are estimated at 54.5 million tonnes. The reserves of the remaining five limestone bands have been estimated at 439 million tonnes. Making allowances for solution cavities, about 215 million tonnes of flux grade limestone will be available from the region. The variation in chemical composition of 21 samples is given below :—

Insolubles	CaO	MgO
0.39—6.56%	47.70—54.05%	0.68—2.49%

Cherrapunji ($25^{\circ}17' : 91^{\circ}44'$).—According to V. K. Raina and M.M. Munshi (Roy, 1962 a) limestone bands, 24 to 36 m. thick, cover an area of

5 sq. km. at about 1.6 km. south of Cherrapunji. The total reserves of limestone between Mawmlah and Mawsnai hills are estimated at 72 million tonnes. Of this, cement grade limestones amount to about 54 million tonnes. Out of 136 analyses, 34 showed more than ten per cent MgO and 102 analyses showed less than five per cent MgO. The range in composition of these 102 analyses is given below :

Insolubles	CaO	MgO
0.18—4.90%	47.33—54.80%	0.40—2.16%

Mawlong (25°13' : 91°42') and Laitryngew (25°20' : 91°44').—Bluish-grey limestone bands can be traced for 150 m. with a thickness of 7.6 m. in this area. Out of 27 chemical analyses only two showed more than ten per cent MgO and the rest had less than two per cent MgO. The range in composition of the limestones is given below :—

Insolubles	CaO	MgO
0.26—3.61%	50.96—54.91%	0.17—1.90%

Jowai Sub-division.—According to A. C. Goswami (Roy, 1962) limestone occurs in the following areas :

(a) *Lumshnong (25°10' : 92°23')-Wynkre area*.—Limestone of Sylhet stage occurs as isolated outcrops and cover an area of 77 sq. km. The CaO content of the lower band varies between 51 and 53 per cent with MgO in traces. The thickness of the lower limestone band varies between 7 m. and 13 m. Reserves of flux grade limestone have been estimated at one million tonnes from the lower band and two million tonnes from the middle band.

The upper band shows 49 per cent CaO and contains two million tonnes of cement grade limestone.

(b) *Garampani or Kopilli (25°32' : 92°37')*.—A workable deposit of limestone occurs about 800 m. east of Larphing (25°30' : 92°40'). The range in chemical composition of four samples of limestone is given below :

Insolubles	R ₂ O ₃	CaO	MgO
1.82—2.34%	1.74—1.82%	51.28—51.46%	0.97—1.27%

The total available quantity of limestone is estimated at 1.6 million tonnes.

(c) *Sutnga (25°22' : 92°27')*.—The limestone belt in this area extends for a length of 1.6 km. with a width varying between 45 m. and 150 m. The range in chemical composition of three limestone samples from this area is given below :

Insolubles	R ₂ O ₃	CaO	MgO
1.08—3.78%	0.84—5.40%	48.65—53.09%	0.72—3.44%

The total workable quantity of limestone has been estimated at two million tonnes.

(4) *Nongkhlih* ($25^{\circ}20' : 92^{\circ}32'$).—Limestone band ranging in thickness from 30 m. to 90 m. form a ridge at about 11 km. east of Sutnga. The limestone band extends for a length of 8km. An analysis of a limestone sample showed 1.04 per cent insolubles, 0.96 per cent R_2O_3 , 53.02 per cent CaO and 0.91 per cent MgO.

Reserves of cement grade limestone have been estimated at 20 million tonnes.

(e) *Lakadong* ($25^{\circ}11' : 92^{\circ}16'$).—Limestone samples analysed from this area show high CaO and very low MgO. The analyses of two samples are given below :

Insolubles	R_2O_3	CaO	MgO
%	%	%	%
1.08	0.50	53.07	1.08
0.86	0.46	53.04	0.92

The reserves of the limestones have not been estimated.

(f) *Syndai* ($25^{\circ}11' : 92^{\circ}09'$).—A narrow belt of Sylhet limestone occurs in this area. Limestones alternating with calcareous sandstones occur in the Nongken hills and vary in thickness from 3 to 12 m.

A band of argillaceous limestone having east-west trend occurs south of the Syndai village. The width of the limestone band is nearly 90 m. with a thickness varying upto 21 m. A sample analysed as follows :

Insolubles	R_2O_3	CaO	MgO
7.88%	5.14%	45.38%	0.40%

About one million tonnes of limestones of cement grade are available from this region.

Shillong Plateau

Nummulitic limestones occur on the Shillong plateau particularly at Umlein ($25^{\circ}13' : 91^{\circ}52'$) and Mawahum ($25^{\circ}14' : 91^{\circ}58'$).

B. R. Narayana Murthy (Krishnan, 1958) reports that the limestone beds associated with the Sylhet limestone stage are used in the manufacture of lime, limemortar and also as a road metal. Thin beds of limestone occur in Pynursla ($25^{\circ}18' : 91^{\circ}54'$), Lyngkyrdem ($25^{\circ}21' : 91^{\circ}54'$), Mawaynram ($25^{\circ}19' : 91^{\circ}36'$) developing into thick beds in Jawai area ($25^{\circ}02' : 92^{\circ}12'$).

Nowgong and Sibsagar Districts

D. K. Chandra (West, 1958) investigated the limestone occurrences in the area confined to the boundary zone between the two districts, Nowgong and Sibsagar. The outcrops are scattered over an area bounded by latitudes $25^{\circ}54'$ and $26^{\circ}5'$ and longitudes $93^{\circ}9'$ and $93^{\circ}40'$ falling in toposheets 83 F/4, 8, 12 and 83 G/1, 5 and 9.

Limestones containing high iron occur between Lunding and Bokajan. The largest among these deposits occur in the Loilapar-Dilaipahar area. These high-iron limestones may be used for the manufacture of "Ferro-Portland cement" which is used for cementing oil-wells.

The reserves of limestones are as follows :

1. For Natural cement 6 million tonnes.
2. For Portland cement 85 million tonnes.
3. For Portland cement in which bauxite is
to be added to raw mixes . . . 63 million tonnes.

United District of Mikir and North Cachar Hills

Extensive deposits of siliceous limestones interbedded with sandstone occur in the following places :

(i) In the Kopili river close to Lobang ($25^{\circ}26' : 92^{\circ}40'$), Palum Pihur ($25^{\circ}29' : 92^{\circ}37'$), Longkingdong ($25^{\circ}29' : 92^{\circ}37'$).

(ii) Between Larphing ($25^{\circ}30' : 92^{\circ}41'$) and Garampani ($25^{\circ}31' : 92^{\circ}37'$). The rock is burnt locally for lime.

REFERENCES

- GOSWAMI, A. C., 1958.—Report of the feasibility of cement manufacture from raw materials available in the Jowai Sub-division, United Khasi and Jaintia hills district, Assam, G.S.I. Report (Unpublished).
- KRISHNAN, M. S. 1958.—General Report for 1954. *Rec. Geol. Surv. India*, Vol. 89, Pt. I, p. 120.
- ROY, B. C., 1962.—General Report for 1958. *Rec. Geol. Surv. India*, Vol. 93, Pt. I, p. 42.
- , 1962.—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, Pt. I, pp. 72—73.
- WEST, W. D., 1950.—General Report for 1948. *Rec. Geol. Surv. Ind.*, Vol. 82, pt. 1, pp. 57-58.

LOCALITY INDEX

Garo Hills district :

Latitude-Longitude

Dalmagri	25°30' : 90°05'
Siju Artheke	25°19' : 90°41'

Khasi and Jaintia Hills district :

Therrighat	25°11' : 91°45'
Shella	25°11' : 91°39'
Cherrapunji	25°17' : 91°44'
Mawlong	25°13' : 91°41'
Laitrymgew	25°20' : 91°44'
Lumalmong	25°10' : 92°23'
Larphing	25°30' : 92°40'
Iutaga	25°22' : 92°27'
Mongkhlih	25°20' : 92°32'
Lekadong	25°11' : 92°16'
Syndai	25°11' : 92°09'
Umloin	25°13' : 91°52'
Nawshum	25°14' : 91°58'
Pynursla	25°19' : 91°54'
Lyngkyrdem	25°31' : 91°54'
Mawaynram	25°20' : 91°36'
Jawai area	25°27' : 92°13'

Nowgong and Sibsagar districts :

Lumding	25°45' : 93°10'
Bokajan	26°00' : 93°45'

United districts of Mikir and North Cachar hills :

Lobang	25°26' : 92°40'
Palum Pihur	25°29' : 92°37'
Longkindong	25°29' : 92°37'
Larphing	25°30' : 92°41'
Garampani	25°31' : 92°37'

BIHAR

Hazaribagh District

The limestones of the district are crystalline and belong to the Archaean age.

(1) *Lapanga* ($23^{\circ}37' : 85^{\circ}23'$).—According to S. N. P. Srivastava (1959), crystalline limestones extend for about nine metres in a south-east to north-west direction with a width of six metres, and is interbedded with calcareous phyllites. Another band of limestone having the dimensions $1.5\text{m} \times 1\text{m} \times 1.5\text{m}$. occur about 225 metres south-east of the above occurrence. The general dip is towards north-east at moderate angles. An analysis of this limestone is given as follows :

Insolubles, 25.70%, R_2O_3 , 1.44%, CaO, 39.65%, MgO, 1.16%.

(2) *Sudi* ($23^{\circ}37' : 85^{\circ}23'$).—According to S. N. P. Srivastava (1959) a crystalline limestone band, 18 m. long and 2.7 m. wide, is intercalated with, calcareous phyllites. To the south of the village there is another small occurrence of limestone two metres long and one metre wide. The range in chemical composition of three analyses is given below :

Insolubles, 8.48—17.00%, R_2O_3 , 0.38—1.60%, CaO, 42.02—48.37%
MgO, 0.15—1.45%.

(3) *Chikor* ($23^{\circ}37' : 85^{\circ}23'$).—According to S. N. P. Srivastava (1959), a crystalline limestone band 66 metres long and 45 m. wide, intercalated with calcareous phyllites, occur about 800 metres south-east of Chikor and dips towards north-east at an angle of 65° . Another band of crystalline limestone 43 m. long and 5 m. wide occur south-west of Chikor. A sample from this place analysed as follows :

Insolubles, 8.34%, R_2O_3 , 0.86%, CaO, 49.76%, MgO, Trace.

The reserves have been estimated at 24,000 tonnes upto a depth of 15m.

(4) *Ladi* ($23^{\circ}37' : 85^{\circ}22'$).—According to Srivastava (1959), thin, discontinuous bands of limestone interbanded with calcareous phyllites extend for about 76 m. in a north-west to south-east direction. The chemical composition of two analyses is given below :

Insolubles	R_2O_3	CaO	MgO
%	%	%	%
12.36	0.86	48.25	0.92
13.46	1.36	46.77	1.48

(5) *Deoria* ($23^{\circ}38' : 85^{\circ}21'$).—According to Srivastava (1959), bands of crystalline limestone run for about 48 m. with a total width of 12 m. There is another 15 m. long band of crystalline limestone on the north-western end of the village. A sample of limestone analysed :

Insolubles, 25.60%, R_2O_3 , 0.36%, CaO, 41.13%, MgO, 0.56%.

(6) *Kori* ($23^{\circ}35'$: $85^{\circ}25'$).—According to S. N. P. Srivastava (1959) bands of crystalline limestone interbanded with phyllites extend for a distance of 390 m. with an average width of 45 m. The direction of dip varies from N.N.E. to north-west with an angle of dip at about 50° . Only one analysis out of a total of 11 showed less than 5 per cent insolubles. The detailed analysis is given below :

Insolubles, 3.10%, R_2O_3 , 0.76%, CaO, 53.39%, MgO, 0.21%.

The variation in chemical composition in the rest of the ten analyses is as follows :

Insolubles, 11.18—30.00%, R_2O_3 , 0.64—1.40%, CaO, 41.73—48.65%, MgO, 0.14—1.83%.

The total reserves have been estimated at 306,000 tonnes.

(7) *Bundu-Basaria* ($23^{\circ}40'$: $85^{\circ}23'$ — $85^{\circ}25'$).—According to S. N. P. Srivastava (1959), a band of crystalline limestone interbedded with phyllites and sericite schists occurs in four disconnected patches in an area 2800 m. long and 1200 m. wide. The band dips at an angle of 60° to the north. The limestone is fine-to coarse-grained. The quality of the limestone is not uniform. One sample from this place analysed as follows :

Insolubles, 3.47%, R_2O_3 , 0.47%, CaO, 53.59%, MgO, 0.62%.

Three samples showed insolubles between 5 and 10%. The variation in chemical composition of these samples is as follows :

Insolubles, 5.87—10%, R_2O_3 , 0.40—0.86%, CaO, 49.23—51.21%, MgO, 0.49—1.9%.

15 samples showed insolubles at more than 10 per cent. The variation in chemical composition of these samples is given below :

Insolubles, 11.83—31.12%, R_2O_3 , 0.58—1.71%, CaO, 35.99—45.28%, MgO, 0.53—1.97%.

The total reserves have been estimated at seven million tonnes down to a depth of 30 m.

(8) *Baskudra-Suiyadih* ($23^{\circ}41'$: $85^{\circ}24'$ — $85^{\circ}25'$).—According to Srivastava (1959), two bands of crystalline limestones occupying areas of 457×137 sq. m. and 639×70 sq. m. respectively occur in this region. The limestone bands dip at an angle of 50° — 70° in a N.N.E. direction in both places. The individual bands are 0.5 to 1 m. thick. The variation in chemical composition in five samples from this region is given below :

Insolubles, 7.52—13.93%, R_2O_3 , 0.50—2.01%, CaO, 46.06—51.04%, MgO, trace to 1.60%.

Reserves have been estimated at 730,000 tonnes.

(9) *Kurkuta-Religara* ($23^{\circ}43'$: $85^{\circ}20'$ — $85^{\circ}22'$).—According to S. N. P. Srivastava (1959), limestones intercalated with phyllites occur over an area of about 2,000 m. by 500 m. The ratio of phyllite to limestone is about 4 : 1. Three samples out of a total of seven showed insolubles less than ten per cent. The variation in chemical composition in three samples is as follows :

Insolubles, 5.70—6.63%, R_2O_3 , 0.41—0.83%, CaO, 51.41—51.53%, MgO, 0.71—0.98%.

The variation in the chemical composition of four samples showing more than 10 per cent insolubles is given below :

Insolubles, 15.36—30.04%, R_2O_3 , 0.75—2.45%, CaO, 35.97—45.94%,
MgO, trace—2.14%.

The total reserves of limestone have been estimated at six million tonnes.

(10) *Bachar (Chenghrvatoli)-Hosir (Hemandagtoli)* ($23^{\circ}40'$: $85^{\circ}05'$ — $85^{\circ}07'$).—According to S. N. P. Srivastava (1959), one limestone zone associated with phyllites runs for about 32 km. with a variable width of 275 to 365 m. The maximum width of a single band is about six metres. The limestones dip to the north-east and north at angles varying between 50° and 70° . The limestone is medium to coarse grained and contains free silica and calcite. It is used in the manufacture of cement, in lime-burning and in foundries.

Two analyses of limestones of this region are given below :

Insolubles	R_2O_3	CaO	MgO
%	%	%	%
16.90	0.60	46.27	0.56
7.90	1.00	51.02	0.68

The total reserves of limestone have been estimated at 4.3 million tonnes down to a depth of 30 metres.

(11) *Korambe* ($23^{\circ}28'$: $85^{\circ}45'$).—According to S. N. P. Srivastava (1959), crystalline limestone associated with calc-granulites and calcareous phyllites cover an area of 304×82 sq. m. on the western fringe of this village. The limestone strikes E-W dipping to north at an angle varying between 55° and 85° . An individual band ranges from few centimetres to 1.5 metres in width. Two chemical analyses of this limestone are given below :—

Insolubles	R_2O_3	CaO	MgO
%	%	%	%
21.44	0.63	43.50	2.36
19.69	0.87	43.87	0.71

The reserves have been estimated at 300,000 tonnes.

(12) *Chak Baurbera* ($23^{\circ}28'$: $85^{\circ}46'$).—According to S. N. P. Srivastava (1959), about eight bands of crystalline limestone associated with calc-silicate rocks dipping steeply to N.N.W. occupy an area of 167×91 sq. m.

The reserves of limestone have been estimated at 52,500 tonnes.

(13) *Toiasaratoli* ($23^{\circ}27'$: $85^{\circ}44'$).—According to Srivastava (1959), crystalline limestone associated with calc-phyllites and calc-silicate rocks, run east to west and occupy an area of 243×106 sq. m. Average composition of limestone is given below :

$CaCO_3$, 76.82% ; R_2O_3 , 0.82% ; MgO, 0.53% and Insolubles, 21.59%.

The reserves have been estimated at 88,900 tonnes.

(14) *sonlinra* ($23^{\circ}28' : 85^{\circ}47'$).—White crystalline limestones associated with calc-silicate rocks occur in an area of 304×152 sq. m. They dip steeply to N. 10° W. Local folding in the limestone bands is very common. The width of individual band varies from 2.5 cm. to 1 metre. The average composition of the limestone is given below.

CaCO_3 , 73.23%, R_2O_3 , 0.58%, MgO , 0.31%, Insolubles, 26.28%.

The reserves have been estimated at 677,000 tonnes.

(15) *Changhrajaratoli* ($23^{\circ}30' : 85^{\circ}47'$) or *Govindpur*.—According to Srivastava (1959), crystalline limestone associated with calc-silicate rocks extends along 1.5 km. in a N.W.-S.E., direction having a north-easterly dip, ranging between 40° and 70° . The zone is about 150 m. wide. The average composition of the limestone in this region is :

CaCO_3 , 73.73%, R_2O_3 , 0.79%, MgO , 0.88%, Insolubles, 25.28%.

The reserves have been estimated at 2.3 million tonnes.

(16) *Upar Barga* ($23^{\circ}29' : 85^{\circ}52'$).—According to Srivastava (1959), a crystalline limestone band associated with calc-silicate rocks, dipping steeply to N.N.E., runs for about 60 m. The width of the limestone bearing zone is 15 m. The average composition of the limestone from this area is as follows :

CaCO_3 , 82.68%, R_2O_3 , 0.46%, MgO , 0.78%, Insolubles, 15.02%.

The reserves have been estimated at 5,600 tonnes.

(17) *Rolakarmajaratola* ($23^{\circ}35' : 85^{\circ}46'$).—According to S. N. P. Srivastava (1959), bands of crystalline limestone associated with calc-silicate rocks and phyllites extend in a N.W.-S.E. direction for over 730 m. with a total width of 90 m.

The limestone bands have a north-easterly dip ranging from 30° to 60° . Average composition of the limestone is as follows :

CaCO_3 , 83.76%, R_2O_3 , 0.60%, MgO , 0.71% and Insolubles, 14.09%.

The reserves have been estimated at 400,000 tonnes.

(18) *Naribandh-Hiaimdag* ($23^{\circ}33' : 85^{\circ}45'$).—According to S. N. P. Srivastava (1959), bands of crystalline limestone occur in an area of 300 m. by 30 m. The average composition of the limestone of this area is as follows :

CaCO_3 , 74.34%, R_2O_3 , 0.79%, MgO , 0.88% and Insolubles, 25.28%.

The reserves have been estimated at 66,600 tonnes.

Dhanbad District

The deposits of limestone near Hansapathar were examined by Khedkar, Ramaswamy and Sastry (1949). The total reserves of crystalline limestone have been estimated at 1,270,000 tonnes, in the deposits at Hansapathar ($23^{\circ}38' : 86^{\circ}39'$), Asta ($23^{\circ}37' : 86^{\circ}41'$), Kulbana ($23^{\circ}37' : 86^{\circ}41'$) and Dhanara ($23^{\circ}38' : 86^{\circ}42'$). The following table of analyses of representative

samples shows that the percentage of insolubles is too high in the rock for its use in the manufacture of cement.

Al ₂ O ₃ %	}		2.25	3.40	1.75	1.25
Fe ₂ O ₃ %						
MgO%	.		1.01	1.70	0.81	0.75
CaO%	.		27.95	29.40	31.99	30.52
Loss on ignition %	.		24.64	[26.71	25.86	25.14
Insolubles %	.		42.38	37.23	38.37	41.28

The search for limestone in the area west of Hansapathar upto the Jharia coalfield, carried out by C. K. R. Sastry and B. Dey separately, did not reveal any deposit.

C. K. R. Sastry (Krishnan, 1953) recorded a band of impure limestone running east-west for 609 m. with an average width of 45.7 m. and a northerly dip of 69° in the southern flank of the hill about one kilometre north of Simmi (23°28' : 86°00'). The deposit is not useful for cement manufacture or for metallurgical industries. A cart track, 12.8 km. long connects this deposit with the Jhalda Railway station on the Ranchi-, Purulia section of the S.E. Railway.

Monghyr District

According to P. K. Ghosh, N. A. Vemban and K. D. Shukla (Krishnan, 1953), a band of crystalline limestone about 1,200 m. in length occurs 800 m. east of Karmatar (24°41' : 86°26'). Small crystalline limestone deposits containing tremolite are traceable at Lernapahar, Kural (24°41' : 86°29') for about 365 m., as a north-south band with a thickness of 30 m. and with vertical dip. The variation in the chemical composition of three samples is given below :

SiO₂, 2.11—5.06%, R₂O₃, 1.20—1.30%, MgO, 1.41—2.7%, CaO, 50.08—52.54%, Loss on ignition 40.86—42.60%.

Small exposures of limestone also occur east of Dhaktari (24°42' : 86°29') and on the north-eastern slope of the Pipra hill (24°41' : 86°29').

About 13.5 million tonnes of limestone are estimated to be present in the Gidhaur Estate. The variation in the chemical composition of seven samples is given below :

SiO₂, 12.73—20.51%, CaO, 36.81—40.46%, MgO, 1.08—1.94%, Loss on ignition 31.55—35.60%.

Palamau District

G. K. Modak (Roy, 1962) investigated the deposits of Archaean crystalline limestone in certain areas of Palamau district included in topo sheets 72 A/1 and 5 and 64 M/13. These include the occurrence near Sua Karia, Telia.

band, Chando, Datum, Satharwa, Sidwadih, Dalsulma, Namudag, Burnmur, Banpahar, Champaria, Harhi Pahar, Berma Chhatra, Gore, Nawadih, Hesra, Sagardihwa, Kundpanitola and Demu.

Almost all the deposits are situated within a radius of 16 to 24 km. from Daltonganj and Latehar railway stations on the Gomoh-Dehri-on-Sone Section of the Eastern Railway.

The limestone occurs as thin lenticular patches or bands. Most of it is coarsely crystalline showing saccharoidal texture. The bands are mostly associated with calc-silicate rocks containing serpentine and diopside, but some of them are also associated with magnetite-tremolite schist.

The general trend of the limestone bands is N.W-S.E with steep south-westerly dip. But some of the bands have a strike in a north-south direction with easterly dips.

A low magnesian limestone belt extends from east to west between Ramgarh and Palamau. The MgO content increases westwards and the limestone deposits west of Koel river such as at Sua ($24^{\circ}00' : 84^{\circ}05'$), Ansan ($23^{\circ}57' : 84^{\circ}08'$) and Bhusami ($23^{\circ}58' : 84^{\circ}09'$) are dolomitic.

Limestones belonging probably to the Kajrahat stage of the Vindhyan system has been reported by G. K. Modak from Chapri ($20^{\circ}24' : 83^{\circ}34'$) and Bajetoli ($24^{\circ}24' : 86^{\circ}36'$) near Bhawanathpur in the Palamau district. It occurs in the plain country and also forms small hills rising from 15 to 30 m. At Chapri, the limestone covers an area of 1200 m. by 165 m., and at Bajetoli it extends for 900 m. having a width of 150 m. The analyses of six samples from this area are given below and on a study of the Table it may be seen that by suitable blending the entire material may be utilised as flux. The deposits are about 56 km. from the The Garwa Road railway station.

Locality		Insol.	SiO ₂	B ₂ O ₃	CaO	MgO	Loss on ignition	Total
		%	%	%	%	%	%	%
Chapri	1	—	6.94	1.78	44.07	5.83	40.63	99.25
	2	10.34	—	1.58	43.01	5.28	39.20	99.38
	3	3.99	—	0.75	45.28	3.70	39.80	99.32
Bajetoli	1	—	3.59	1.01	51.40	1.66	41.67	99.33
	2	—	5.52	1.50	49.12	2.38	40.72	99.24
	3	—	6.23	1.65	46.84	3.63	40.88	99.23

R. Thiagarajan (Roy, 1964) recorded the occurrence of bands of impure crystalline limestones containing streaks and patches of calc-silicate minerals at Balatala ($24^{\circ}03' : 84^{\circ}05'$), Basu ($24^{\circ}10' : 84^{\circ}05'$), Chanda ($23^{\circ}57' : 84^{\circ}06'$), Chianki ($24^{\circ}01' : 84^{\circ}07'$), Datam ($23^{\circ}57' : 84^{\circ}03'$), Hurmur ($24^{\circ}55' : 84^{\circ}15'$), Kadhwan ($24^{\circ}12' : 83^{\circ}58'$), Kauria ($24^{\circ}59' : 84^{\circ}06'$), Khambi ($24^{\circ}01' : 86^{\circ}58'$), Kundri ($24^{\circ}10' : 84^{\circ}10'$) Murma ($25^{\circ}55' : 84^{\circ}17'$), Salatua ($24^{\circ}01' : 83^{\circ}58'$) and Semra ($24^{\circ}00' : 83^{\circ}59'$). Reserves are estimated at 84,700 tonnes to a depth of 15 m. at Sua ($23^{\circ}59'45'' : 84^{\circ}06'$). The proportion of limestone to calc-silicate minerals varies from 1 : 4 to 1 : 10. Lenticular bands of dolomitic limestones are reported by M. N. Balasubramanyam near Pahargarwa ($24^{\circ}13' : 83^{\circ}58'$), Khambi and Sagardinua.

From 1962, the Geological Survey of India is investigating the limestone deposits near Konmandra, Dhanimandra, Gargawan, Ghagra and Saraia in the Bhaunathpur area. Detailed mapping of parts of these blocks show that there are two main horizons of limestone in the area. One of them consists of two bands of limestone which are exposed in the Dhanimandra and Konmandra areas. The second horizon consists of a thick band of limestone which is exposed in the Gargawan and Sheopahar areas where it is estimated to be about 40 m. thick. Near Saria the outcrops are quite wide.

Sampling is being done and as agreed upon with M/S Hindustan Steel Ltd. the samples are being handed over to them for analysis in their laboratory.

The reserves as estimated by Sugavana (1963) are given below :

Deposits	Expected reserve
I. Konmandra North	1,666,500 tonnes
II. Konmandra South	3,270,400 tonnes
III. Dhanimandra	1,612,800 tonnes
IV. Saraia	499,800 tonnes
V. Gorganwan North	350,000 tonnes
VI. Gorganwan South	140,000 tonnes
Total net expected reserves	7,539,000 tonnes

Shahabad District

Major limestone bands belonging to the lower part of the Rohtas stage of Vindhyan system occur over a length of 75 km. between Jaradag ($24^{\circ}32' : 83^{\circ}32'$) and Ramdhira ($24^{\circ}47' : 84^{\circ}1'$) within the district. They are exposed at a number of places as natural outcrops or exposed by quarrying. The aggregate thickness of the limestone varies from 20 to 30 m. There are three main bands west of Chutia ($24^{\circ}33' : 83^{\circ}45'$), the silica content is mostly above 12 per cent. But between Chutia and Ramdhira, the topmost portion of the second limestone band has a three metre-thick zone with less than six per cent silica and four per cent magnesia. On the basis of detailed sampling, nearly 12 million tonnes of Steel Melting Grade and 48 million tonnes of Blast Furnace Grade limestone in addition to 30 million tonnes of cement grade limestone have been estimated by Nautiyal *et. al.* from the exposed areas, lying between Ramdhira and Harriara (Jadunathpur) ($24^{\circ}32' : 83^{\circ}36'$). The deposits in the individual areas are described below :

Ramdhira area.—The Ramdhira quarry is at two kilometres N.N.W. of Ramdhira railway station. It is 1.6 km. long along the scarp and 15 m. above the general ground level. There are five bands of limestones, which are from the bottom 3m., 0.6m., 1.3m., 1.6m. and 0.3m. thick, and are interbedded with shale. They occur within a section of thickness of 16 m. The

limestone is thinly-bedded, light grey in colour, fine-grained and compact. Nine samples from three bands were analysed. The CaO content varies from 43.89 to 49.76 per cent; MgO from 1.41 to 4.12 per cent; and insolubles from 5.49 to 13.69 per cent. Weighted averages of insolubles for four bands are as follows:

Thickness of the band in metres	Insolubles %
4	8.8
2.5	8.8
1.2	8.12
1.5	5.49

Uttni Quarry area.—This area is about 2.5 km. W.N.W. of the Tumba railway station. A 4.2 m. thick limestone band is exposed in this quarry. Seven samples were analysed. The CaO content varies from 44.9 to 51.5 per cent; MgO content from 0.6 to 2.9 per cent; and insolubles from 6.7 to 11.1 per cent. The weighted average of insolubles of three samples representing a three metres thickness is 9.67 per cent. The reserves of this three metre thick furnace grade band, having a length of 300m. and a width of 120 m. are estimated at 0.27 million tonnes.

Banjari area.—There are three major bands. The lowermost is 14.2 m. thick and the other two are 6.7 m. and 2.4 m. thick. The bands are separated by varying thickness of shale. Twenty-eight samples were analysed. The CaO content varies from 41.32 to 51.41 per cent; MgO from 0.53 to 3.62 per cent; and insolubles from 3.63 to 16.62 per cent.

In one section out of a total thickness of 37.8 m., the bottom 8.4 m. is of cement grade limestone and within the remaining part, an aggregate of nearly eight metres thick limestone is with 6 to 11 per cent insolubles and less than three per cent magnesia while an additional 8.5 metre thickness contains less than six per cent insolubles and less than three per cent magnesia.

Reserves :

S. M. S. Grade :	Length of the band . . .	4 km.
	Average thickness . . .	3.5 m.
	Assumed workable width . .	100 m.
	Reserves	3.5 million tonnes
B. F. Grade :	Length of the band . . .	3.9 km.
	Average thickness . . .	7 m.
	Assumed workable width . .	120 m.
	Reserves	8.19 million tonnes
Cement grade :	Length of the band . . .	4 km.
	Average thickness . . .	6 m.
	Assumed workable width . .	100 m.
	Reserves	6 million tonnes

Kauriari area.—The locality is about eight kilometres north of Rohtas railway station. Below a thickness of 30.4m. in cherty shale, there is about nine metres of highly calcareous shale containing five limestone bands

which are individually less than one metre in thickness. Five analyses from this area show CaO from 41.27 to 45.60 per cent, MgO, 3.9 to 6.96 per cent and insolubles from 6.70 to 11.6 per cent.

Murli Hill area.—This area is situated north-east of Rohtas railway station. It is an isolated hill 800 m. long and 450 m. broad at the base. Limestone and shale are exposed at the base of the hill and are overlain by the Lower Kaimur sandstone. In the quarry sections, all the limestone bands are exposed. They vary from one to ten metres in thickness with an aggregate thickness of 20 m. in a section 47 m. thick. Sixteen analyses show CaO content from 38.3 to 50.12 per cent, MgO from 1.31 to 5.1 per cent, and insolubles from 5.18 to 20.3 per cent.

Reserves :

S. M. S. Grade :	Length of the band . . .	600 m.
	Average thickness . . .	1.65 m.
	Assumed workable width . .	150 m.
	Reserves	0.37 million tonnes
P. F grade :	Length of the band . . .	600 m.
	Average thickness . . .	12 m.
	Assumed workable width . .	150 m.
	Reserves	2.7 million tonnes

Baulia-Chunahatta area.—This area includes the Baulia main quarry Nahadro Kho K-6 quarry, Baraicha and Chunahatta quarries. There are three major limestone bands. The topmost band varies in thickness from 2.4 to 3.6 m. The second band varies in thickness from 3 to 6.3 m. and is separated from the first by a shale of 1.5 to 5.4 m. in thickness. The major band at the bottom is 10.5 to 12 m. in thickness. A further thickness of about 40 m. of shale below this major limestone band contains thin bands of limestone one of which is 2.4 m. thick. Between the second and the bottom major bands, there is a thickness of about 17 m. of shale within the bands of limestone.

In the Baulia area, 12 analyses show CaO from 40.32 to 49.90 per cent, MgO from 0.22 to 4.71 per cent, and insolubles from 4.71 to 16.30 per cent. In the Chunahatta area, 27 analyses show CaO from 42.65 to 50.48 per cent, MgO from 0.72 to 2.89 per cent and insolubles from 4.50 to 15.3 per cent.

Reserves :

S. M. S. Grade :	Length of the band . . .	6,400 m.
	Average thickness . . .	3 m.
	Assumed workable width . .	100 m.
	Reserves	5.8 million tonnes
B. F. Grade :	Length of the band . . .	6,000 m.
	Average thickness . . .	9 m.
	Assumed workable width . .	120 m.
	Reserves	16.2 million tonnes
Cement Grade :	Length of the band . . .	6,000 m.
	Average thickness . . .	6 m.
	Assumed workable width . .	120 m.
	Reserves	10.8 million tonnes

Dhanauti area.—One three metre thick and other minor bands from 0.3 to 1.5 m. thick limestone are found in a section of 13.1 m. The aggregate thickness of limestone bands is 5.8 m.

Reserves :

S. M. S. Grade :	Length of the band	150 m.
	Average thickness	3 m.
	Assumed workable width . . .	120 m.
	Reserves	135,000 tonnes
B. F. Grade :	Length of the band	150 m.
	Average thickness	4 m.
	Assumed workable width . . .	120 m.
	Reserves	180,000 tonnes.

Dabhua area.—A 12 m. thick limestone band is exposed immediately below Lower Kaimur sandstones. Below this and separated by 13.5 m. of shale, there are 3.3 and 1.2 m. thick limestone bands. This is followed below by a 60 m. thick section of shale with thin limestone bands. Eleven analyses show CaO from 41.74 to 50.85 per cent, MgO from 0.66 to 2.89 per cent, and insolubles from 5.36 to 14.66 per cent.

Reserves :

S. M. S. Grade :	Length of the limestone band . .	1,600 m.
	Average thickness	2.7 m.
	Assumed workable width . . .	120 m.
	Reserves	1.29 million tonnes
B. F. Grade :	Length of the limestone band . .	1,500 m.
	Average thickness	4.2 m.
	Assumed workable width . . .	120 m.
	Reserves	1.89 million tonnes.

Lusiani area.—Two limestone bands of 12 m. and 10 m. thickness are separated by 16.5 m. thick shale.

Chutia (Tura-Pipardih) area.—There are four major limestone bands, two at the base and two near the top within a section of 81 m. The top band is 10 m. thick and below that a metre-thick band is separated by 24 metre-thick shale. The bottom band is six metres thick and above that a 15 m. thick band is separated by 5.4 m. shale. Thirty-eight analyses from this area show CaO content from 42.9 to 47.2 per cent, MgO from 0.9 to 4.30 per cent, and insolubles from 9.92 to 14.18 per cent.

Reserves :

B. F. Grade :	Length of the limestone band	600 m.
	Average thickness	10 m.
	Assumed workable width . . .	120 m.
	Reserves	1.8 million tonnes.
Cement grade :	Length of the limestone band	600 m.
	Average thickness	7.5 m.
	Assumed workable width . . .	120 m.
	Reserves	1.35 million tonnes.

Gatiahi area.—There are three limestone bands in a section of 144 m. thickness. The top band is nine metres thick. At the bottom there is a six metres thick band above which, separated by 10·5 m. of shale and shaly limestone, there is a 21 m. thick limestone band. Fifteen analyses show CaO ranging from 42·25 to 48·27 per cent, MgO from 1·32 to 2·86 per cent, and insolubles from 8·9 to 15·65 per cent.

Reserves :

B. F. Grade :	Length of the limestone band	600 m.
	Average thickness	21 m.
	Assumed workable width	180 m.
	Reserves	5·4 million tonnes
Cement Grade :	Length of the band	600 m.
	Average thickness	7·5 m.
	Assumed workable width	180 m.
	Reserves	2·02 million tonnes.

Doma-area.—There are two limestone bands, a top 24 m. band and a bottom six metre-band separated by 16·5 m. thickness of shale. Thirteen analyses show CaO from 35·65 to 45·04 per cent, MgO from 1·63 to 2·81 per cent, and insolubles from 13·1 to 24·45 per cent. Six analyses show CaO from 44·6 to 45·98 per cent, MgO from 2·07 to 3·12 per cent, and insolubles from 8·72 to 12·83 per cent.

Reserves ;

B. F. Grade :	Length of the limestone band	3,000 m.
	Average thickness	10·5 m.
	Assumed workable width	120 m.
	Reserves	9 million tonnes
Cement Grade :	Length of the limestone band	3,000 m.
	Average thickness	10 m.
	Assumed workable width	120 m.
	Reserves	9 million tonnes

Hariara area.—The Hariara hill is north of Jadunathpur village. There are four limestone bands of thicknesses (from the top) 18 m., 9 m., 6 m., and 4·5 m. within a section of 90 m. Seven analyses show CaO from 39·44 to 43·95 per cent, MgO from 1·29 to 3·44 per cent, and insolubles from 13·51 to 19·67 per cent. Six more analyses show CaO from 44·09 to 45·43 per cent, MgO from 0·77 to 2·36 per cent, and insolubles from 9·17 to 12·01 per cent.

Reserves ;

B. F. Grade :	Length of the limestone band	450 m.
	Average thickness	16·5 m.
	Assumed workable width	150 m.
	Reserves	2·76 million tonnes
Cement Grade :	Length of the limestone band	450 m.
	Average thickness	9 m.
	Assumed workable width	150 m.
	Reserves	1·51 million tonnes.

Ramkho area.—This area is located 500 m. west of Hariara. There are four bands of limestone 7.1, 10.5, 3, and 1.5 metres thick within a section of 39m.

Fourteen analyses show CaO from 42.81 to 49.82 per cent, MgO from 1.37 to 3.92 per cent, and insolubles from 4.83 to 12.04 per cent. Thirty more analyses show CaO from 37.46 to 45 per cent, MgO from 0.81 to 2.94 per cent, and insolubles from 13.4 to 26.78 per cent. One sample shows 15.17 per cent magnesia and 12.08 per cent insolubles.

Jaradag area.—At this place, there are two main limestone bands 19.8 m. thick (top band) and 16.8 m. thick (lower band) separated by 12.3 m. thick shale. Fourteen analyses show CaO from 37.23 to 42.48 per cent, MgO from 1.07 to 4.61 per cent, and insolubles from 12.80 to 23.71 per cent. One sample is dolomitic with 15.52 per cent MgO and 11.97 per cent insolubles.

Ranchi District

M. K. Roy Chowdhury (Krishnan, 1954) reported the calc-tufa occurrences of no economic value in the vicinity of Dhibadihtoli ($23^{\circ}16' : 84^{\circ}26'$) and Balato ($23^{\circ}19' : 84^{\circ}23'$).

Granular limestone occurs to the south of Gutua ($23^{\circ}16' : 84^{\circ}23'$) and to the south of Bagru Hill near the village of Chot Chorgain ($23^{\circ}28' : 84^{\circ}26'$). These are of no economic importance.

Crystalline limestone deposits having east-west strike occur between Babhana-Hoyar-Khalari ($23^{\circ}38' - 23^{\circ}40' : 85^{\circ}00' - 85^{\circ}04'$). At Khalari, the limestone is massive and is suitable for the manufacture of cement. The limestone bands have widths varying from 150 m. to 240 m. Crystalline limestone also occurs in Durdu-Ray area.

Santhal Parganas District

C. S. Raja Rao reported the occurrence of kankar in the soil at many places in the Rajmahal hills and in the surrounding area.

Singhbhum District

Small deposits of impure crystalline magnesian limestone, belonging to the Iron Ore series, occurs at Putada springs ($22^{\circ}33' : 85^{\circ}48'$), Singhbhum district.

Analysis of limestone at Putada springs is given below :

SiO₂ 2.5%, Fe₂O₃ 0.24%, CaO 32.69%, Na₂O 0.88%, Al₂O₃ 1.6%, MgO 15.96%, K₂O 0.13%, Loss on Ignition 45.53%.

Massive limestone also occurs at Ghatkuri ($22^{\circ}78' : 85^{\circ}34'$) and south of Patang ($22^{\circ}23' : 85^{\circ}24'$).

Limestones belonging to the Kolhan series occur intermittently from Chaibasa to Jagannathpur ($22^{\circ}13' : 85^{\circ}39'$) over a distance of about 48 m. They are variable in thickness attaining the greatest near Rajanka ($22^{\circ}26' : 85^{\circ}44'$).

The average of 60 chemical analyses of these limestones is given below :

R_2O_3 0.86% ; CaO 50.58% ; MgO 0.53% ; Insolubles 8.29% ; Loss on ignition 39.78% .

S. N. P. Srivastava (1958) located new deposits of limestone on a hill lying about a kilometre north of Mahulbasa ($22^{\circ}51' : 86^{\circ}19'$) and in the southern portion of Chagaltopa pahar ($22^{\circ}51' : 86^{\circ}20'$).

REFERENCES

- DUNN, J. A.—Economic Geology and Mineral Resources of Bihar. *Mem. Geol. Surv. Ind.*, Vol. 78.
- KHEDKAR, V. R., RAMASWAMY, T. K. & SASTRY, C. K. R., 1948-49.—Report on the crystalline limestone in the area around Hansapathar, Manbhum district, Bihar (unpublished).
- KRISHNAN, M. S., 1954.—General Report for 1945. *Rec. Geol. Surv. Ind.*, Vol. 79, Pt. II, p. 673.
- , 1953.—General Report for 1950. *Rec. Geol. Surv. Ind.*, Vol. 84, Pt. I, pp. 83-84.
- , 1958.—General Report for 1953. *Rec. Geol. Surv. Ind.*, Vol. 87, Pt. I, p. 106.
- MAHADEVAN, T. M. and PRASAD, U., 1956.—Report on the Mineral Resources of Kharia State, Bihar (unpublished).
- NARASIMHA RAO, Ch. 1956-57.—Geological Mapping and preliminary investigations of crystalline limestone in parts of Ranchi and Hazaribagh districts, Bihar (unpublished).
- NAUTIYAL, S. P., CHAKRABORTY, M., MANDWAL, N. K., POULOSE, K. V., PRASAD, R. N. and MAZUMDAR, N.—A Report on the investigation of flux-grade limestone in Rohtas belt, Shahbad district, Bihar, G.S.I., Report (unpublished).
- ROY, B. C., 1962.—General Report for 1956. *Rec. Geol. Surv. Ind.*, Vol. 91, Pt. I, pp. 77-78.
- , 1962 (a).—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. I, p. 43.
- , 1962 (b).—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, Pt. I, p. 43.
- , 1962 (c).—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, Pt. I, pp. 73-74.
- , 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.*, Vol. 95, Pt. I.
- SRIVASTAVA, S. N. P., 1959.—Investigation of limestone deposits in the Thanas of Hunterganj, Barkagaon, Ramgarh, Gola, Ganita and Mandu in the Hazaribagh district, Bihar.
- SUGAVANAM, E. B., 1963.—Investigation for flux-grade limestone around Bhaunathpur, Palamau district, Bihar (unpublished).
- WEST, W. D., 1950.—General Report for 1949. *Rec. Geol. Surv. Ind.*, Vol. 83, Pt. I, pp. 139-140.

LOCALITY INDEX

Hazaribagh district :

Latitude-Longitude

Lapanga	23°38': 85°25'
Sudi	23°37': 85°23'
Chikor	23°37': 85°23'
Ladi	23°37': 85°22'
Deoria	23°38': 85°21'
Kori	23°35': 85°25'
Bundu-Basaria	23°40': 85°23'.85°25'
Baskudra	23°41': 85°24'.85°25'
Kurtuta	23°43': 85°20'.85°22'
Bachra	23°40': 85°05'
Korambe	23°28': 85°45'
Chak Baurora	23°28': 85°46'
Toiasaratoli	23°28': 85°44'
Sondimra	23°29'. 85°47'
Chaughrajaratoli	23°30': 85°47'
Upar Barga	23°29': 85°52'
Rolas Karmajaratola	23°35': 85°40'
Haribandh-Hiemdag	23°33': 85°45'

Dhanbad district :

Hansapathar	23°38': 85°39'
Asta	23°37': 86°41'
Kulbana	23°37': 86°41'
Dhanara	23°38': 86°42'
Simmi	23°28': 86°00'

Monghyr district :

Karmatar	24°41': 86°26'
Kural	24°41': 86°29'
Pipra hili	24°41': 86°29'

*Palamau district :**Latitude-Longitude*

Sua	24°00': 84°05'
Ansan	23°57': 84°08'
Bhasami	23°58': 84°01'
Chapri	20°24': 83°34'
Bajitoli	24°24': 86°37'
Balatala	24°03': 85°05'
Basu	24°10': 84°05'
Chauda	23°57': 84°06'
Chianki	24°01': 84°07'
Datam	23°57': 84°03'
Hurmur	24°55': 84°15'
Kadhawan	24°12': 83°58'
Kauria	24°59': 84°08'
Khambi	24°01': 86°58'
Kundai	24°10': 84°10'
Murma	25°55': 84°17'
Salatua	24°01': 83°58'
Semra	24°01': 83°40'
Pahargarwa	24°13': 83°58'

Shahabad district :

Jaradag	24°32': 83°32'
Ramdhira	24°47': 84°01'
Chutia	24°33': 83°45'
Hariara (Jadunathpur)	24°32': 83°36'
Banjari	24°40': 83°55'
Kauriari	24°40': 83°55'
Murli hill	24°36': 83°55'
Baulia Chunahatta	24°37': 83°51'
Dhanauti	25°20': 84°25'
Dabhua	24°34': 83°48'
Chutia (Turapipardih)	23°20': 84°05'

*Shahabad district :**Latitude-Longitude*

Dema	24°20' : 83°05'
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Ram-Kho	24°31' : 83°36'
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Ranchi district :

Balato	23°19' : 84°23'
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Gutua	23°16' : 84°23'
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Dhibadihtoli	23°16' : 84°26'
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Chorgain	23°28' : 84°26'
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Babhna-Hoyar-Khalari	23°38' : 23°40' : 85°00' : 85°04'
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Singbhum district :

Putada Springs	22°33' : 85°48'
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Ghatkuri	22°18' : 85°24'
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Jagannathpur	22°13' : 85°39'
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Rajanka	22°26' : 85°44'
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Baghmara	23°39' : 86°45'
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GUJARAT

Amreli district

According to C. Karunakaran (Krishnan, 1958 a), limestone deposits in this district are grouped into (i) limestones in the Gaj series (Miocene) and (ii) Miliolite limestone (Quaternary). The former is associated with shales, marls and ochre and can be distinguished by their colour and rather close association with marls and clays. Unlike the former the younger miliolite limestones are buff coloured, fine-grained, rather porous, arenaceous and impure.

Area around Port Albert Victor

Chanch island (20°57' : 71°37').—The limestone deposits occur over the entire island and crop out over a length of about 6.0 km. with an average width of about 400 m. The limestone is buff coloured, sandy, porous, rather friable and current-bedded and occurs as generally horizontal or gently inclined beds. The chemical analysis of these samples gave 59.37 to 67.10% of CaCO_3 . The limestone contains impurities as silica and iron and aluminium oxides.

Visalia (21°3' : 71°36').—The limestone obtained from several shallow pits within an area of about 84 sq. m. about 1.5 km. E.S.E. of Visalia village and about 8 km. east of Port Albert Victor, is seen to be cream or brown in colour, thin-bedded, sandy, porous and very friable. One sample analysed 89.62 per cent of calcium carbonate. The deposit does not appear to be economically important.

Danterdi (21°3' : 71°38').—The dry river bed south of this village shows outcrops of compact brownish limestone. The limestone is also seen a few metres further to the south, upto a depth of about 6 m. Disconnected outcrops of limestone are seen further west along the road side upto Dudhala (21°3' : 71°43') over a distance of about 11 km. This limestone deposit is not considered economically important.

Chanchuda (20°55' : 71°31').—South-west of Port Albert Victor, towards Chanchuda, the low ground contains a few outcrops of limestone. Near Rampura (20°56' : 71°31'), a few pits show horizontally bedded limestone about 1 m. thick. The limestone contains 67.10 per cent of CaCO_3 . North of the creek, there are shallow quarries on the coast which show horizontal layers of limestone up to 1.2 m. thick. West of these pits lies a ridge trending in an easterly direction for about 500 m. from the coast with an elevation of at least 6 m., consisting entirely of limestone with a thin overburden of dune sand.

The limestone from the quarries contain 91.11 per cent of CaCO_3 .

Bhakodar (20°54' : 71°27').—Two wells at the village, one 18.28 m. deep and the other 9.14 m. deep, run entirely through limestone. The limestone at a depth of about three metres from the surface is massive, compact and thick-bedded. Underlying this, the limestone is very friable, porous and apparently sandy.

Limestone quarries with an average thickness of about three metres are situated west of the village. Similar limestones occur in the ridges of the area and extend upto Vararup near the sea coast. A groove sample cut from a vertical quarry face contained 90.45 per cent of CaCO_3 . This limestone appears to be of high grade and deserves detailed investigation.

According to Burjor Mehta (Krishnan, 1954b), a patch of nearly 8 sq. km. lying between the village of Vararup to the south-east and Vand to the north-west comprises limestone and sand dunes. The limestone near the coast dips at 10° to the east and at Vand it dips at 26° to the north. In this area, the top 90 cm. to 1.5 m., section consists of a honeycombed, hard and compact variety of limestone, the strata underneath being of the softer type. Two representative samples from Vararup show the following analyses :—

	(1) Vararup	(2) East of Vararup.
$\text{SiO}_2\%$	14.20	11.06
$\text{Al}_2\text{O}_3\%$	2.03	2.70
$\text{Fe}_2\text{O}_3\%$	2.07	1.07
$\text{MgO}\%$	0.86	1.26
$\text{CaO}\%$	43.63	46.20
Loss on ignition %	35.46	35.90

In the Vararup -Vand area the limestone deposits are suitable for use in the manufacture of cement as the analyses show CaCO_3 content varying from 77 to 83 per cent and the magnesia content is less than 2 per cent. About 16 million tonnes of material have been estimated upto a depth of 1.5 m.

Near Conchdi ($21^\circ 15' : 72^\circ 05'$) also, an occurrence of yellow, clayey limestone associated with a thin fossiliferous limestone of Oligocene to Lower Miocene age has been reported. According to B. C. Roy (1953) coral limestone occurring along the coastal margin of Okhamandal analyses 95.94% of CaCO_3 ; 2.22% of SiO_2 ; 0.16% of Fe_2O_3 ; 0.60% of Al_2O_3 ; and 0.12% NaCl . The deposits are 1.5 to 3 m. thick. The reserves near Mithapur alone are about five million tonnes.

Deposits of limestone occur in the coastal areas around Kodinar. Deposits near Adivi, Dholasa and Harmaria in the Kodinar area contain an average 93% of CaCO_3 ; 1.2% of MgCO_3 ; 1.6% of R_2O_3 and 3% of SiO_2 .

Calcite :—Krishnaswamy (1943-44) carried out a detailed investigation of the calcite deposits in parts of Amreli. The following notes are based on his work.

The important occurrences are known as Panala deposits and are located about 500 m. west of Ingorala ($21^{\circ}13' : 71^{\circ}14'$), on the northern outskirts of the Gir forest, possibly extending for a length of 2.5 km. west wards. The principal veins are lenticular and are found in the low hillocks to the south and south-east of Panala hill ($\Delta 1113$ ft.) and down the southern banks of the latter hill, in association with greenish porphyritic traps intruded by basic dykes. The veins have a variable strike, their general direction being W.N.W.—E.S.E. The shallow test pits show that these veins persist in depth generally upto about three metres. About 58,000 tonnes of calcite can be won from this area within this depth. The veins on Panala hill are associated with a white siliceous rock.

About 1.1-1.5 km. north and north-east of Ingorala, there are two small parallel veins of calcite running discontinuously in an E.N.E.—W.S.W. strike. They are generally more cherty than calcareous. According to R. Bruce Foote, these veins form part of the long Jikiali and Kotada veins, which extend discontinuously for some 22 km. from Gadhia in the west to beyond Jikiali ($21^{\circ}15' : 71^{\circ}15'$) in the east into the adjoining Bhavnagar State.

Banaskantha district

Limestone deposits in this district consist of marbles of the Archaean group and crystalline limestone of the Delhi system of Cuddapah age. B. C. Roy (West, 1949) made a detailed investigation of the crystalline limestone deposits near Pasuval ($24^{\circ}28' : 72^{\circ}22'$), Diwania ($24^{\circ}22' : 72^{\circ}44'$), Khunia ($24^{\circ}22' : 72^{\circ}41'$) and Karamudi ($24^{\circ}22' : 72^{\circ}46'$). The limestone occurs in association with calc-silicate rocks, granites and gneisses. The samples analysed in the Geological Survey Laboratory gave the following results :—

	Pasuval	Diwania	Khunia	Karimudi
SiO ₂ %	0.60	1.45	6.24	21.50
Al ₂ O ₃ %	2.62	0.50	0.89	6.77
Fe ₂ O ₃ %	0.88	0.40	0.51	1.93
CaO%	51.09	51.08	50.37	37.49
MgO%	1.27	3.29	3.02	2.85
Loss on ignition %	42.28	42.62	38.94	26.42

The available reserve at Pasuval and Diwania is more than 10 million tonnes. The material is suitable for cement. The Khunia deposits contain 20,000 tonnes of pure crystalline limestone within a depth of 15 m. and is suitable for the manufacture of cement. In the Karimudi area within a strip of about 1500 m. by 300 m., over 15 million tonnes of the material may be available within a depth of 15 m. from the surface. The other crystalline limestone deposits in Palanpur, referred to by A.M. Heron and P. K. Ghosh (Roy 1951) are located near Gangu ($24^{\circ}22' : 72^{\circ}40'$), Bhaldi ($24^{\circ}28' : 72^{\circ}23'$), Gangavada ($24^{\circ}28' : 72^{\circ}26'$), Katada ($24^{\circ}26' : 72^{\circ}23'$), Bhilachal ($24^{\circ}26' : 72^{\circ}26'$) and Hadmatiya ($24^{\circ}25' : 72^{\circ}27'$). These have not been examined in detail.

Marbles of Aravalli age (Archaean) occur near Piloti (24°32':72°28'). They are used for burning lime and for building purposes. A typical Piloti marble contains 49.6% of CaO; 3.5% of MgO; 3.9% of Insolubles and 0.67% of R₂O₃.

Baroda district

Burjor Mehta (1951-52) has recorded the occurrence of marble near Chuchupura (22°13':73°38').

The siliceous limestones to the south of Narukot (22°23':73°42'), north of Ghanta (22°28':73°40') and Nathpura (22°29':73°42') appear to be too poor for any industrial use. Thin bands (1.52 to 4.57 m. wide) of limestone occurring between Jair (22°22':74°02') and Rajpur (22°19':74°24') and associated, with white dolomite belonging to the Aravalli suite of rocks are worked for use in cement-tile and glass industry.

A deposit of limestone and white marble extends over a distance of 11 km. near Jhor in Chota Udepur. Other occurrences in this region are near Mithibor, Kundol, Chetapur, Chena, Malu and Bhilpur, all in Chota Udepur.

Bhavnagar district

According to K. P. Sinor (1927), the Miliolite limestone deposits in this district occur at Piperla (21°40':71°54'), Sansora (21°44':71°48'), Chogat, (21°49':71°55'), Methla (21°10':72°04'), Maip (21°06':71°56') and Gujarda (21°02':71°47'). The deposits in Gondal are found near Jar, Patanawao, Zinjuda, Upleta and Paneli. The material from this area is used in chemical industry. Numerous deposits of Miliolite limestone are found all over the former Nawanagar State and a few localities in the Gope area.

Burjor Mehta (Roy, 1961) investigated the reported occurrence of limestone deposits near Bhavnagar (21°47':72°09'). Buff coloured Miliolite limestone, at times showing 10° to 20° dip towards south or south-east and intercalated with sandstone, etc., occurs in an area within the limits of Janijhmer (21°11':73°06'), Madhuvan (21°10':72°05') and Dial (21°08':72°59'). It is located about 80 km. to the south of Bhavnagar. Whereas in the area around Janijhmer, near the coastline the thickness of the deposits as seen from the existing quarries is of the order of over 15 m., the other deposits covering the traps near Sanosra, etc., are shallow with a maximum thickness varying from 1.5 to 3 m. The limestone varies from a hard and compact type to one that is soft and crumbles to powder when struck with a hammer. According to Mehta, about 15 million tonnes of limestone may be available from around Janijhmer and about 5 million tonnes from Sanosra and adjoining areas.

Nine representative samples from different localities in the Janijhmer area show that the CaO and MgO content varies from 45.02 to 49.72 % and 0.36 to 0.76 % respectively. Three samples from the Sanosra area show the CaO content varying from 40.89 to 43.93 % and MgO from 1.12 to 1.74 %.

Calcite: K. P. Sinor (1927) noted some calcite veins, partly appearing as marble, near Abhrampur. They are reported to be sporadic and are not of large extent. Judging from extensive deposits in adjacent areas, it is probable that large workable veins are present in parts of Bhavnagar.

Broach district

Mehta (1950) investigated the following occurrences of limestone in the Rajpipla division :—

Vanji and Shir :—Grey coloured Cretaceous limestone forms the knolls and hillocks covering about 1.5 sq. km. between Vanji (21°54':73°48') and Shir (21°54':73°49'). It dips at 25° to 30° to the south-east. Cream and yellow coloured limestone beds overlie the grey variety. The average thickness of the workable material would be in the neighbourhood of 4.5 to 6 m. Assuming an average thickness of 5.5 m. about 5,000,000 tonnes may be available from this locality.

Gora :—Dark greyish, flaggy limestone occurs about 3 km. south-east of Gora (21°52':73°41'). The beds which are at times much disturbed and crumpled, dip nearly at 30° to the south-east. The area covered by the limestone on the left bank of the Narbada river is roughly 93,000 sq. m. About 2,000,000 tonnes of material may be available here. The CaO content varies from 22 to 39%.

Bhilod :—Yellow, fossiliferous, Tertiary limestone occurs on the right bank of the Amravati river near Bhilod (21°36':73°12'), Bharan (21°30':73°2'), and Kondh (21°35':73°5'). The thickness of the beds as well as the quantity available is small.

Ambakhadi :—Calc-tufa occurring along the *nala* near Ambakhadi (21°44':73°18') varies in thickness from 0.3 to 0.6 m. and extends over a length of 152 m. A thick bed of cream coloured travertine, in small lenticular pockets, is noticed on the right bank of a *nala* at Rakhaskundi (21°38':73°17'). Other smaller deposits occur near Bhilvasi (21°15':73°39') and Tejpur (21°46':73°17'). The material from all these localities is used for lime burning.

The Cretaceous limestone occurring between Survani (21°53':73°48'), Vanji (21°54':73°49'), and Limkhetar (21°55':73°51') varies from 1.5 to 9.1 m. in thickness and extends discontinuously for about 5 km. The material appears to be high in silica.

Analyses

	Near Vanji	Vanji North	Vanji West	Gora East	Gora West
Al ₂ O ₃ %	2.70	4.50	2.20	6.70	4.80
Fe ₂ O ₃ %					
MgO%	1.15	1.98	0.58	2.88	3.17
CaO%	21.95	38.92	37.79	37.37	32.81
Loss on Ignition %	20.00	32.90	30.64	32.22	28.38
Insolubles	54.24	21.28	28.26	20.54	30.62

The samples represent siliceous low, magnesia limestone which are unsuitable for the manufacture of cement.

Burjor Mehta (1950) also examined the following occurrences of calcite veins in the Broach district.

A vein mixed with quartz runs in a N.W.-S.E. direction in amygdular trap to the east of Sajanava ($21^{\circ}42':73^{\circ}20'$). It is traceable for about 75 m. and is about one metre in width.

A north-south trending vein forms a knoll in the country about 1.5 km. south-west of Ambakhadi ($21^{\circ}44':73^{\circ}18'$). It is traced for over 60 m., and is 9 m. wide, possibly extending down to a depth of about 1.5 to 2 m. Some of the calcite is transparent and of good quality, but mostly mixed with quartz and stained dark brown.

A north-west striking vein extends for about five metres in the trap country, 1.5 km. east of Amatyhar ($21^{\circ}42':73^{\circ}14'$). It is about 6 to 25 m. long. Small stringers of calcite are also noted at Dali ($21^{\circ}47':73^{\circ}20'$), Bamamfalia ($21^{\circ}48':73^{\circ}22'$) and near Khadagda ($21^{\circ}55':73^{\circ}42'$) though the total quantity estimated is about 3,500 tonnes, the calcite does not seem to be suitable for use in the optical industry. It may be used for making high grade lime.

Dangs district

Apart from a few isolated small pockets of travertine, occurring near Chinchinagotha, Satpuriya ($20^{\circ}48':73^{\circ}31'$) and Dhadra ($20^{\circ}49':73^{\circ}33'$), no deposit of any limestone was observed by Burjor Mehta (1930).

Quaternary calc-tufa and *kankar* have also been recorded at Chinchinagotha ($20^{\circ}48':73^{\circ}33'$), Satpuriya and Dhadra.

Junagadh district

B. C. Roy (Krishnan, 1955) has reported high grade Miliolite (Pleistocene) limestones near the Chorvad Road Railway station ($21^{\circ}3':70^{\circ}20'$), Kinderwa ($21^{\circ}0':70^{\circ}21'$), Adri Road Railway station ($20^{\circ}59':70^{\circ}22'$), Dari ($20^{\circ}57':70^{\circ}22'$), Veraval ($20^{\circ}54':70^{\circ}25'$), Savai ($20^{\circ}57':70^{\circ}29'$), Patan ($20^{\circ}53':70^{\circ}27'$), Lati ($20^{\circ}52':70^{\circ}29'$), Gorakhmudi ($20^{\circ}54':70^{\circ}35'$), Prachi ($20^{\circ}55':70^{\circ}39'$), Sutrapara ($20^{\circ}51':70^{\circ}31'$), Warodra ($20^{\circ}49':70^{\circ}34'$), and other places.

The length and breadth of the deposits around Savni are about 3 km. and 1 km., around Adri 2 km. and 1 km., around Dari about 1.5 km. and 0.5 km., and around Sutrapara 2 km. and 1 km. respectively.

The Miliolite limestone at Veraval has been noticed extending to Patan, a distance of about 5 km., with width ranging between 0.48 to 0.8 km.

Roy carried out a detailed examination of Miliolite limestone deposits in Gorakhmudi, by sinking a number of shallow pits. About 147,000 tonnes of high grade limestone may be available in a strip of country about 1.5 km. long and 500 km. wide, within a depth of 500 m. from the surface. The purer limestone bands are homogenous, fine-grained or compact, and are white, pale yellow or grey in colour. Their thickness varies between 0.3 and 0.9 m. It is estimated that there are about 300,000 tonnes of good grade limestone within a depth of 1.5 m. from the surface.

Deposits from a few metres to 30.5 m. in thickness are reported west of Nagesri. A sample from near Rajpura ($20^{\circ}46':71^{\circ}07'$) analysed 52.16% of CaO, 0.93% of MgO, 2.54% of SiO_2 , and 0.64 % R_2O_3 .

Area around Jafrabad

Babarkot-Mitjala area :—According to Burjor Mehta (1952), extensive deposits of limestone together with wind blown calcareous sand dunes cover an area of about 13 sq. km. between Babarkot ($21^{\circ}52' : 71^{\circ}24'$) and Mitjala ($20^{\circ}53' : 70^{\circ}35'$). The limestones dip at angles varying from 20° to 30° . In the Jafrabad ($20^{\circ}52' : 71^{\circ}22'$) and Vadhera ($20^{\circ}53' : 71^{\circ}19'$) area, the top (0.3 to 1.8m.) consists of a buff coloured, hard and compact limestone while at depth it is an indifferently cemented softer variety 15.2-30.4 m. thick.

Analyses of representative samples of limestones from the Babarkot-Mitjala area gave the following results :—

	East of Babarkot	Localities North-West of Babarkot	1.5 km. South of Mitjala
$\text{SiO}_2\%$	4.48	3.52	7.52
$\text{Al}_2\text{O}_3\%$	0.66	0.88	1.06
$\text{Fe}_2\text{O}_3\%$	1.94	1.52	1.14
MgO%	0.54	0.82	0.86
CaO%	51.15	51.62	49.62
Loss on Ignition %	40.72	41.28	33.60

The above analyses show that the limestones from localities (1) and (2) have a CaCO_3 content varying from 91.33 to 92.17 per cent with less than one per cent of MgO. A specimen from locality (3) contains 88.60 per cent of CaCO_3 with less than one per cent of MgO. Over 27 million tonnes of the material will be available upto a depth of about 1.5m.

The lower layers of the deposits around Babarkot are sometimes friable and sandy or mere chalk.

Area west of Jafrabad Creek

According to Mehta, buff coloured Miliolite limestone with a regional dip varying from 12° to 32° to the north-east and covering an area of about 9 sq. km. occurs around Jafrabad. An area of nearly 4 sq. km. is available for exploitation of the limestone. A study of these quarry sections shows that out of an average depth of 4.5 to 7.6 m. of the limestone only the top 1.2 to 1.8 m. of the material is of a hard and compact nature, the

remaining comprising a softer variety of rock. A 9.1 m. wide band of a light cream coloured hard and compact limestone, dipping 30° towards east, occurs near Masankodi ($20^\circ 51' : 70^\circ 33'$). A *nala* section exposes thickness of about 6 m. of this limestone. Laterally this band extends for over 400 m. A similar band is again noticed about 1.5 km. west of this point along the coast.

Analyses of limestone from different horizons and localities in the Jafrabad area give the following results :

	Localities				
	E. of Jafrabad	W. of Jafrabad	32 km. west of Jafrabad	South-coast of Jafrabad	Masnkoadi
	1	2	3	4	5
SiO ₂ % . . .	13.88	13.72	3.02	3.58	2.36
Al ₂ O ₃ % . . .	3.32	4.55	1.49	0.48	0.72
Fe ₂ O ₃ % . . .	3.88	4.05	0.81	1.92	0.68
MgO%	1.96	1.68	0.62	0.64	0.23
CaO%	42.04	39.54	51.76	51.25	51.63
Loss on Ignition% .	33.68	36.52	41.84	40.92	42.44

The above analyses show that the CaCO₃ content of the limestone from localities (3), (4) and (5) is more than 90 per cent and magnesia below one per cent. In (1) and (2) the magnesia content is less than two per cent, and the CaCO₃ content varies between 70 and 76 per cent. Thus all the analyses show that limestone of a suitable quality required for the manufacture of cement is available in this area. About 16 million tonnes of this material will be available for exploitation within a shallow depth of about 1.5 m. from the surface. The limestone area is roughly rectangular, elongated in an east-west direction for a distance of 3.2 km. with a width of 1.6 km. At the northern limit there appears to be several parallel ridges the northern most of which is being quarried at several places containing sandy impure limestone mixed with much soil. A parallel ridge to the south consists of uniformly grained and well-bedded limestone. Analyses of two samples from the northernmost ridge gave the following results :—

1. SiO₂—21.40%, CaCO₃—65.8%
2. CaCO₃—60.20%

Further south towards the sea coast several quarries are seen. These show a top layer of hard compact limestone about two metre thick with indistinct bedding. A groove sample cut out of this layer showed 87.86% of CaCO₃ and 6.08 % of SiO₂.

A cream coloured, fine-grained limestone is seen in a limited area in Masankodi. This is overlain and underlain respectively by buff coloured, porous, current-bedded limestone. This show 88.16 per cent of CaCO_3 . Further west near the sea coast a few working quarries are located. A groove sample gives :—

SiO_2 —7.8%, CaCO_3 —85.09%

The sections between Jafrabad and the sea coast to the south usually show a top layer, a few centimetre thick, of hard limestone below which the stone is uniformly soft, porous and buff coloured. The chemical analysis of a sample from this area give : SiO_2 —6.12%, CaCO_3 —90.15%. Further south there are some larger quarries which supply stone to the lime kilns. A sample show 86.82 per cent of CaCO_3 .

The limestone ridges seen near Jafrabad were traced along the strike in an easterly direction almost upto the sea coast south of Vadera ($20^\circ 53' : 71^\circ 19'$) for a distance of 4.8 km. Here the limestone outcrop is about 400 m. wide. Two samples analysed as follows (i) CaCO_3 —72.14% ; (ii) CaCO_3 —82.75%.

A sample of the dune sand at this place contain 55.56% of CaCO_3 . Traversing further west the low ridges of limestone disappear about 5 km. east of the Rohisa village ($20^\circ 50' : 71^\circ 16'$) about 13 km. west of Jafrabad. The limestone contains 86.84% of CaCO_3 .

Dharabunder ($20^\circ 49' : 71^\circ 14'$) :—About 300,000 tonnes of limestone have been estimated from this area. One sample analysed CaCO_3 —88.08%.

South of Dharabunder at the seashore there is another high ridge of limestone which extends in a north-easterly direction upto Jafrabad. The limestone is sandy and rather impure. It shows CaCO_3 —70.01%. The ridge consists of stratified limestone dipping generally in a northerly direction at 10° to 30° . The lower part of the limestone is ferruginous and powdery.

Khajundara ($20^\circ 47' : 71^\circ 7'$) :—Several quarries are situated in the limestone outcrops around Una. The limestone sample shows CaCO_3 —92.42%.

C. Karunakaran (1954) describes the limestone deposits in the following areas :—

Area around Veraval ($20^\circ 55' : 70^\circ 23'$) :—Limestone deposits extend from Prachi ($20^\circ 55' : 70^\circ 37'$), 27.3 km. east of Veraval to Mangrol ($21^\circ 08' : 70^\circ 07'$), 32.1 km. NW. of Veraval.

Cream coloured, compact and massive limestone occurring in the area east of Veraval shows 92.37 per cent CaCO_3 . A few important limestone deposits are described below :

Jaleshwar near Veraval :—Good quality, cream coloured and compact limestone underlain by hard buff sandy limestone occurs in this area. The chemical analysis of a sample from the upper layer gives 77.41% of CaCO_3 .

Dhola Khoda in Khorasa and Samadhiala village :—An average sample from the pits and quarries gives 93.96% of CaCO_3 .

The limestone near Khorasa village is perforated with solution holes. A groove sample shows 78.11% of CaCO_3 . The limestone outcrop has been traced over an area of over 38 hectares and persists to a depth of at least three metres.

About 16 km. north-east of Veraval, on the road to Talala, the river Hiran has cut through horizontal strata to a depth of over three metres. A chip sample from the cliff face in the river gave 87.82% of CaCO_3 . The limestone deposit appears to be fairly extensive.

Another fairly extensive outcrop of limestone occurs further west in the area known as Gabha. The limestone is typically horizontally bedded Miliofite limestone, grey to buff coloured, rarely with white bands. The deposit is about 1.5 km. in length and 200 m. in breadth. The chemical analyses show CaCO_3 varying from 68.31 to 82.33%. The area between Veraval and Mangrol, contains many outcrops of limestone. Near Maktampur ($21^{\circ}8' : 70^{\circ}6'$), the quarries show horizontally bedded limestone at the surface with very little overburden of soil. Underlying this, there is a band, about 1.5 m. thick, of distinctly bedded limestone which shows CaCO_3 —89.06%.

West of Lohi ($21^{\circ}10' : 70^{\circ}4'$) the limestone is persistent but is ferruginous. At Sil ($21^{\circ}11' : 70^{\circ}3'$) a well section shows limestone bands of 6 m. thickness.

Limestone outcrops are seen further north-west upto Madhavpur ($21^{\circ}15' : 70^{\circ}01'$), a distance of 11.2 km. The limestone is uniform, perfectly bedded and horizontal. One sample gives 63.63 % of CaCO_3 .

Area around Porbandar ($21^{\circ}39' : 69^{\circ}35'$)

The limestone deposits occur near Gosa ($21^{\circ}31' : 69^{\circ}44'$), about 22.5 km. south-west of Porbandar, and Aditiyana ($21^{\circ}43' : 69^{\circ}42'$) about 14.5 km. north-west of Porbandar.

Limestone occurs extensively in the low ground around Aditiyana. Here the limestone is hard and fine-grained, light pink and is riddled with solution holes. The quarries are usually 9-15 m. deep; the deepest quarry situated in one of the higher ridges (Dhaba quarry) is 30 m. deep.

The limestone ridge in which the above mentioned quarries are situated was traced at intervals further north upto a *nala* called Vandrajara, about 3 km. south of Ranpur ($21^{\circ}50' : 69^{\circ}41'$). The limestone ridge extends further east from this locality.

This limestone formation extends from Ranpur in a southerly direction to Aditiyana and beyond Ranawao, for a length of at least 24 km. Limestone is also reported from north of Ranpur and east of Ranava at several places towards Kutiyana ($21^{\circ}38' : 69^{\circ}59'$).

Chemical analyses of a number of samples from these limestone show CaCO_3 from 90% to 95%.

Calcite :—S. Krishnaswamy (1943-44) examined the calcite deposits in parts of Junagadh. The following information is based on his work :—

A number of calcite veins are found around Gadhagra ($21^{\circ}15' : 71^{\circ}26'$). The most important deposit is located about one kilometre S. 29° W. of Ramgadh ($21^{\circ}15' : 71^{\circ}24'$). This vein crops out with a strike E. N. E.—W.S.W. in a discontinuous manner for about 2 km. in Junagadh territory, before extending into the adjoining Bhavnagar area. About 28,000 tonnes

of calcite could be won from this deposit within a depth of 4.5 m. There are, in addition, two other large veins, one about 3 km. to the south-east of Gadhagra, close to the border of the Bhavnagar State and about 2 km. to the south-west of that village up to the Gadhagra Railway station road. A number of small calcite veins also occur to the north, north-east and south of that village. They are associated with purplish brown porphyritic traps, intruded by basic dykes.

S. Krishnaswamy (1943-44) also recorded numerous small occurrences of opaque calcite in the trap rocks in the Gir forest in Jungadh in the following localities :—

- (1) 3.2 km. S. S. W. of Sarakaria ($21^{\circ}0' : 71^{\circ}5'$).
- (2) One km. E.N.E. of Itvaya ($20^{\circ}56' : 71^{\circ}0'$) where there is a small deposit of greyish white crystalline limestone or marble.
- (3) Nearly 1.5 km. N. N. E. of Itvaya ($20^{\circ}56' : 71^{\circ}0'$).
- (4) 2.5 km. almost due east of Kantala ($21^{\circ}2' : 71^{\circ}12'$).
- (5) 2.4 km. to the east of Khardhar ($21^{\circ}5' : 71^{\circ}15'$).
- (6) 2.2 km. west of Khardhar.
- (7) About 3 km. N.N.E. of Khardhar. Here two parallel bands of moderately crystalline rock, about 0.6 to 0.9 m. thick dipping at high angles, occur in a zone 1.6 km. long and 2.1 m. wide.
- (8) About 1.5 km. west of Khambha ($21^{\circ}9' : 71^{\circ}17'$), there is a 3.6 m. wide band of crystalline limestone, with small crystals of calcite in the matrix.
- (9) 3.2 km. W.S.W. of Khambha, on the high western slopes of the spur of a big hill range, north of Dhantravari river.
- (10) About 3 km. W.S.W. of Khamba, from the north-eastern flanks of a low hillock.

In the traps, calcite veins, 90 cm. in thickness are reported by J. M. Master (1942-43) about 3 km. south of Malia, on the western bank of the Mangal river, and north-east of Keshod. The deposit at the former place is said to be 457 m. long.

According to Burjor Mehta (1942-43), minor veins of calcite are present in traps to the south of the Bhesan township.

Adye (1917) records a narrow vein in traps 2.2 km. N.N.W. of Bhatakri, in Porbandar. The area is strewn with geodes of onyx, chalcedony and quartz.

B. C. Roy (1953) noted some specimens of calcite from Adwana and Bhagwada in the Porbandar taluk. The material is being used at the works of Messrs Porbandar Industrial Products for preparing a white powder.

Burjor Mehta (1942-43) records calcite veins in traps at the following localities :—

- (1) A 2.1 m. thick, east-west striking vein, 3.2 km. west of Adwana.
- (2) A 90 cm. wide, east-west striking vein S. S. W. of (1), exposed for 15.2 m. at the surface.
- (3) A 2.4 m wide, north-south, vein about 365 m. east of (2).
- (4) 1.5 km. north of Bakharla.

Kaira district

P. N. Mukherjee (1948) examined the eastern extension of limestone probably of Lameta age occurring as patches along the fringe of the Deccan trap near Gundela ($23^{\circ}06' : 73^{\circ}22'$). The deposits consist of massive siliceous and gritty limestone which sometimes contain veins of calcite, cherty or jasperoidal intercalations and conglomeratic beds. It is estimated that at least a couple of million tonnes of siliceous limestone will be available. Samples analysed show that the percentage of insolubles varies from 43.56 to 72.60%, R_2O_3 from 0.40% to 1.00%, CaO from 13.11% to 31.67% and MgO from 0.98% to 8.59%. This material could be used for lime burning.

In Balasinor, almost horizontal beds of limestone overlie the granites unconformably, but towards the northern limits of the State, the limestone is seen to rest over Aravalli phyllites, mica-schists, and quartzites.

The reserves have been estimated at about 812 million tonnes. At least a couple of million tonnes are suitable for the manufacture of cement. The deposit is about 18 km. from the Sewalia railway station.

The analyses of some samples are given below :—

Sample Nos.	1	2	3	4	5	6
Insoluble% . . .	5.9	1.9	3.6	3.8	2.3	0.2
R_2O_3 % . . .	0.6	0.2	1.3	0.6	0.6	0.6
CaO% . . .	30.14	54.26	49.85	31.64	53.41	55.10
MgO% . . .	1.02	0.24	1.33	0.68	0.64	0.61

1. 400 m. south of Haria ($22^{\circ}51' : 73^{\circ}21'$)
2. 3.2 km. south-west of Balasinor ($22^{\circ}56' : 73^{\circ}20'$)
3. 800 m. N. N. W. of Chaklasi tank ($22^{\circ}58' : 73^{\circ}20'$)
4. 1.2 km. west of Kunjra ($22^{\circ}58' : 72^{\circ}18'$)
5. 400 m. S. S. W. of Bhajia kiari ($23^{\circ}01' : 73^{\circ}19'$)
6. 800 m. N. N. E. of Bir ($22^{\circ}59' : 73^{\circ}10'$)

Kutch district

B. C. Roy (Krishnan, 1953) examined the limestone deposits in the coastal area near Lakhpat ($23^{\circ}50' : 68^{\circ}45'$). Limestone crops out along the strike almost continuously between Lakhpat and Ghuner ($23^{\circ}48' : 68^{\circ}51'$), a stretch of nearly 6.5 km. The width of the formation varies from 91.5 m. to several hundred metres. The beds vary from 1.5 to 6m. in thickness, and are gently dipping or horizontal. The limestone is pale yellow or white, sometimes marly in appearance, and is characterised by the usual presence of nummullites. A sample on analysis show : SiO_2 —8.48%, Fe_2O_3 —4.6%, CaO—49.33%, MgO—2.56%, loss on ignition—39.26%. The limestone is suitable for the manufacture of cement.

Eocene Nummullitic limestone also occurs to the east of Adesar ($23^{\circ}33' : 71^{\circ}02'$), between Adkudi ($23^{\circ}24' : 70^{\circ}35'$) and Badargari ($23^{\circ}28' : 70^{\circ}41'$) near Chitror ($23^{\circ}24' : 70^{\circ}44'$) and east and north of Umarsar ($23^{\circ}45' : 68^{\circ}54'$).

Bhuj and Nakhtrana taluk :—M. C. Poddar (Krishnan, 1958) examined the occurrence of oolitic limestone bands on the northern flank of the Jhura dome ($23^{\circ}26' : 69^{\circ}38'$) in the Bhuj *taluk* and on the southern flank of Keera dome ($23^{\circ}55' : 69^{\circ}17'$) in the Nakhtrana *taluk*. The oolite limestone stage consists of a number of bands of varying texture and composition. The average thickness of limestone bands, is approximately 11 to 12 m. The chief minerals, besides calcite, are limonite and hematite, with disseminated quartz-grains.

Analyses of different samples of limestone revealed fairly high amount of carbonates of calcium and minor magnesia, besides alumina and silica.

Seven representative samples of Golden oolite limestone, (a) three from the Jhura dome and (b) four from Keera dome were chemically analysed, and the results are summarised below :—

	1	2	3	4	5	6	7
SiO ₂ % (a) . . .	2.68	0.48	5.24	5.10	4.02	4.52	3.20
(b) . . .	5.30	3.50	6.70	9.00	—	—	—
Al ₂ O ₃ % (a) . . .	3.75	20.20	10.80	2.75	3.76	2.94	2.12
(b) . . .	4.88	2.68	1.78	1.69	—	—	—
Fe ₂ O ₃ % (a) . . .	22.63	13.32	17.55	18.31	7.35	18.48	27.56
(b) . . .	31.92	18.01	16.52	12.99	—	—	—
FeO% (a) . . .	0.22	1.28	1.34	0.85	1.52	0.88	1.28
(b) . . .	0.49	0.55	0.36	0.30	—	—	—
MgO% (a) . . .	2.97	1.32	1.32	1.26	1.1	1.42	1.44
(b) . . .	1.33	1.30	1.13	1.52	—	—	—
CaO% (a) . . .	36.93	30.96	32.54	37.74	38.63	39.12	34.02
(b) . . .	26.28	38.05	37.89	40.01	—	—	—
Total Sulphur % (a) . . .	0.20	—	—	—	—	—	—
(b) . . .	—	—	—	—	—	—	—
V ₂ O ₅ % (a) . . .	Trace	—	—	—	—	—	—
Loss on Ignition (a) . . .	30.60	30.78	31.01	33.02	32.33	32.80	30.04
(b) . . .	29.00	35.17	35.36	34.22	—	—	—

The reserves are estimated to be about 9.6 million tonnes in the Jhura dome and about 9.4 million tonnes in the Keera dome.

M. C. Poddar (Krishnan, 1958a) carried out investigation of Tertiary limestone deposits of western Kutch. Foraminiferal limestones lie between latitudes $23^{\circ}20'$ and $23^{\circ}45'$ and between longitudes $68^{\circ}32'$ and $69^{\circ}0'$, in topo-sheets 41 A/9, 10, 11, 13, 14 and 15 covering an area of about 388 sq. km. The limestone stage lies conformably over the gypseous shale of Laki age and underlies the arenaceous stage of Oligocene age.

At the south-eastern part around Ramania, the thickness of the limestone is 19.8 m. at Waghapadar 64 m., at Hurdi-Ber 94.5 m., and at Lakhpat 50 m. The lower band is fairly thick and massive, approximately over 27 m. thick. A thickness of 26 m. over a length of several kilometres should be workable.

Analyses of 30 limestone samples collected from different localities and horizons indicate the following variation in composition :—

SiO ₂		0.58 to 5.85 %.
R ₂ O ₃		0.09 to 4.82 %.
CaO		38.52 to 53.31 %.
MgO		0.38 to 10.60 %.

It is obvious from the above analyses that much of the limestones are of a quality suitable for cement manufacture. Some of the analyses indicate that parts of the bands are of a high degree of purity and may be found suitable for important industrial uses.

Abadasa taluk and Khavada mahal :—M. C. Poddar (Roy, 1961) investigated the Gaj and Middle Jurassic limestones occurring in the southern and northern parts of Kutch. About 12 samples have been collected at random (4 samples from the Middle Jurassic and the remaining from the Gaj beds) from Khavada mahal ($23^{\circ}50'$: $69^{\circ}46'$) and Abadasa taluk. The results of the chemical analyses show that the Middle Jurassic limestones are suitable for the manufacture of cement whereas the Gaj limestones are unsuitable for that purpose due to the presence of high percentage of MgO. The reserves of the Middle Jurassic limestone are supposed to be several hundred million tonnes. M. C. Poddar (Krishnan, 1954 b) reports the sporadic occurrence of calcite in the trap region south of Chadsisa ($23^{\circ}06'$: $69^{\circ}23'$) in the Mandvi taluk, Kutch. The lumps break along the cleavage planes and are smoky to colourless in appearance. Poddar (Roy, 1961) also reports the occurrence of calcite crystals in veins occurring in the traps around Boch and Beraja villages (41 F/9 and 13) in western Kutch.

Naunagar district

Adye (1914) records many calcite veins filling fissures in traps at Naunagar sometimes in the form of branching veins near Virpur, on the west bank of the Moti Puljar river, and in the vicinity of Pithadia. Minor veins are reported from the following places :—

- (1) 2 km. S.S.E. of Rinjpur, about 9.5 km. S.S.E. of Lalpur, partly in association with aragonite.

- (2) 0.4 km. south-east of Khirasra, 4 km. north-west of Lalpur. Here a N.N.W.—S.S.E. vein exposed for 164.5 m. shows a maximum width of 1.2 m.
- (3) 0.4 km. S.S.E. of Govania, a 45.7 m. long branching vein strikes N.E.—S.W. and is 0.4-1.2 m. wide.
- (4) 0.8 km. north of Wadala on the road side to Narmana, showing a north-south vein.
- (5) 1.6 km. south of Narmana, 32 km. S.S.E. of Jamnagar, exposing a couple of large, parallel north-south veins.
- (6) About one km. W.S.W. of Wadala, showing a large N.W.—S.E. vein.
- (7) 0.4 km. south of Sarwania, 5.2 km. S.S.W. of Khalawad, where a thick deposit is struck in a well.
- (8) South of Katkola, 8 km. north of Wansjalia railway station exposing numerous anastomosing veins, 0.05 to 0.15 m. wide.
- (9) About 6.5 km. E.S.E. of Sarodar, where a vein, 0.3 m. wide, runs from N.N.W. to S.S.E. of Dhoraji.
- (10) 2.8 km. E.N.E. of Darwi, 16 km. N.N.E. of Kandorda, showing thin irregular veins on the hilly ground.
- (11) At the base of Nana Baghudio Dhar, 0.8 km. S.S.E. of Kih-jaria, 18.5 km. north-west of Kandorna, exposing an irregular vein.

According to Roy (1953), numerous vertical or highly inclined calcite veins, 0.3 to 1.5' m. wide, with a strike between N.E.—S.W. and N.W.—S.E. are present as fissure fillings in the vesicular traps in the Jamnagar area. They are worked generally upto a depth of 3-6 m. but 9-10.6 m. deep pits are also noticed at places. The bigger veins run uniformly for long distances, from a few metres upto a couple of kilometres or more in the form of single veins along the strike. A large part of the veins is concealed below a cover of black soil or miliolite limestone; the total thickness of the overburden goes upto 1.5 m.

Roy referred to a number of localities where calcite has been worked from time to time in the Halar area by Messrs. Jamnagar Minerals Development Syndicate. They are mentioned below :—

- (1) Panchkoshi *taluk*—Konza and Alia Bada.
- (2) Khambalia *taluk*—Sinhan, Khasota and Sirsaro.
- (3) Lalpur *taluk*—Rafa Khatia, Rafudal, Govindia, Jashapur, Jogwad, Chikari, Mahadevia, Rasangpur, Pipli, Sapur, Navugam, Vili, Rangpur, Modpur and Dharampur.
- (4) Kalawad *taluk*—Moti Matli, Nana Matli, Modpuru Vavdi, Sahavania and Vijarkhi.
- (5) Vanthali *taluk*—Veratiya, Pithadia and Hadmatia.
- (6) Kalyanpur *taluk*—Sidsara and Asota.

Samples of calcite showed the following results on analysis:—

	Moti Matli	Sarvania	Govania
CaCO ₃ %	96.49	96.77	96.20
MgCO ₃ %	2.48	2.33	2.96
Al ₂ O ₃ and Fe ₂ O ₃ %	0.45	0.25	0.25
SiO ₂ %	0.31	0.33	0.27

Panchmahals district

The reported occurrence of limestone at Poyell (22°28' : 73°45') was found by Burjor Mehta (1958) to be too siliceous and high in magnesia to be used in cement manufacture.

There is an occurrence of impure magnesian limestone near the northern borders of the former Jambughoda State. The width of outcrops is over 150 m. and the band is traceable for over 3 km. A deposit of siliceous limestone is noted near Usarwan (22°52' : 74°17') within 3.2 km. of the Dohad railway station. According to Awate of the State Industries Department, limestone and marble are also present in the former Baria State.

P. N. Mukherjee (1945) examined the occurrence of limestone of Lameta age from the eastern border of the State. Massive limestone, with stringers of cherty or chalcedonic material occupies an area of about 1.5 sq. km. and is extensively utilised locally for lime burning.

Sabarkantha district

Burjor Mehta (1951) reports the existence of compact dark grey, slaty limestone, dipping at 30° E.S.E. in a hill north of Malasa (23°49' : 73°11').

The limestone is about 9-12 m. thick and covers an area of 0.65 sq. km. A band of marble in association with quartzites is noted to the east of Bhetali (23°44' : 73°20'). The strike is roughly N.N.E.—S.S.W. and is 91.5 m. in width. A 60 cm. thick band of travertine is seen along a *nala* south-east of Dadhalia (23°34' : 73°25'). It is confined to a strip about 122 m. long, and is used for lime burning.

V.R. Venkoba Rao (Roy, 1962 a) investigated the limestone belt (4.8 km. to 9.6 km. wide) stretching over a length of 48 km. from Vadali (23°57' : 73°03') in the south upto the district boundary in the north. The area is included in topo-sheets 45 H/3 and 4 and forms a part of the Khedbrahma taluk. The quality of the limestone varies considerably from place to place, showing 31 to 53% of CaO and 0.36 to 3.00% of MgO. The reserves of cement grade limestone may be sufficient to sustain a small cement factory.

Surat district

Burjor Mehta (1945) investigated the occurrence of limestone near Tadkeshwar (21°23' : 73°06'). The area to the north and N.E. of Tadkeshwar as well as near Pet Talao, consists of yellowish brown, massive, fossiliferous Nummulitic limestone of Tertiary age, occurring just below the ground level. The beds dip about 10° to the south-east. The reserves in the Tadkeshwar area will be about 0.7 million tonnes and that of the Pit Talao area about 2 million tonnes.

Judging from the analyses, carried out in the Geological Survey of India laboratory, the limestone appears to be suitable for the manufacture of cement.

REFERENCES.

1. Adye, E.H., 1914—Economic geology of Navanagar State, p. 105-107.
2. ———, 1917—Economic geology of the Porbandar State.
3. Fox, C.S., 1946—The mineral resources of Baroda State, p. 23-27.
4. Krishnaswamy, S., 1942-43—Progress report for 1942-43 G.S.I. Report (unpublished).
5. ———, 1943-44—A note on the Gadhagra calcite deposits, Junagadh State, Kathiawar. G.S.I. Report (unpublished).
6. ———, 1943-44—A note on the calcite deposits near Ingorala village, Amreli pranth, Kathiawar. G.S.I. Report (unpublished).
7. Karunakaran, C., 1954—Report on Reconnaissance of limestone deposits in Southern Saurashtra. G.S.I. Report (unpublished).
8. Krishnan, M.S., 1953—General Report for 1950. *Rec. Geol. Surv. Ind.* Vol. 84, Pt. I, p. 47, 84 and 85.
9. ———, 1954—General Report for 1945. *Rec. Geol. Surv. Ind.* Vol. 79, Pt. 2, pp. 673-74.
10. ———, 1954 b—General Report for 1952. *Rec. Geol. Surv. Ind.* Vol. 86, Pt. I, p. 85.
11. ———, 1955—General Report for 1946. *Rec. Geol. Surv. Ind.* Vol. 79, Pt. 2, p. 809.
12. ———, 1958—General Report for 1958. *Rec. Geol. Surv. Ind.* Vol. 87, Pt. I, p. 70, 106 and 111.
13. ———, 1958 a—General Report for 1954. *Rec. Geol. Surv. Ind.* Vol. 86, Pt. I, p. 121.
14. La Touche, T.H.D., 1918—Bibliography of Indian Geology, Pt. 1-B, p. 34, 36.
15. Master, J.M., 1942-43—Report on mineral investigation in Junagadh State, Kathiawar. G.S.I. Report (unpublished).
16. Mehta, Burjor, 1942-43—Report on mineral investigation of the Porbandar State, Kathiawar. G.S.I. Report (unpublished).
17. ———, 1942-43—Report on mineral investigation of the Junagadh State, Kathiawar. G.S.I. Report (unpublished).
18. ———, 1944-45—Report on the suitability of the limestone, occurring near Tadkeshwar, Surat district, Bombay Presidency. G.S.I. Report (unpublished).
19. ———, 1950—Report on the occurrence of limestone near Chinchinagaottha in the Dangs district, Bombay Presidency. G.S.I. Report (unpublished).
20. ———, 1950-51—Summary of field work.
21. ———, 1944-45—Report on the geology of Visavadar and parts of Keshod and Vanthli mahals of Junagadh state and adjoining area. G.S.I. Report (unpublished).

REFERENCES—*concl'd.*

22. Mehta, Burjor, 1952—Report on the occurrence of limestone and gypsum around Jafrabad, Saurashtra. G.S.I. Report (unpublished).
23. ———, 1949-50—Summary of field work.
24. Mukherjee, P.N., 1943-46—Progress reports for 1943-46. G.S.I. Report (unpublished).
25. Mukherjee, P.N. and Gupta, B.C.—The Geology of Gujarat and Southern Rajputana, *Rec. Geol. Surv. Ind.*, Vol. 73, Pt. 2, p. 202.
26. Roy, B.C., 1962 a—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, Pt. I, pp. 42-43.
27. ———, 1962—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. 1, p. 46.
28. ———, 1961—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, Pt. 2, p. 71, 119 and 120.
29. ———, 1957—Investigation of economic minerals and rocks in parts of Saurashtra. G.S.I. Report (unpublished).
30. ———, 1953—Economic Geology and Mineral Resources of Saurashtra.
31. ———, 1953—The calcite deposits of Saurashtra.
32. ———, 1951—Mineral Resources of Bombay.
33. Sinor, K.P., 1927—Petrographic descriptions of the igneous and sedimentary rocks of the Bhavnagar Territory, p. 70.
34. West, W.D., 1949—General Report for 1947. *Rec. Geol. Surv. Ind.*, Vol. 81, Pt. 1, p. 59.

LOCALITY INDEX

<i>Amreli district.</i>	<i>Latitude—Longitude :</i>
Chanch Island	20°57' : 71°37'
Visalia	21°03' : 71°36'
Dauterdi	21°03' : 71°38'
Dudhala	21°03' : 71°43'
Chauchuda	20°55' : 71°31'
Rampura	20°56' : 71°31'
Bhakodar	20°54' : 71°27'
Vararup	20°56' : 71°25'
Oouchdi	21°15' : 72°65'
Okhamaudal	22°15' : 69°00'
Mithapur	20°55' : 71°20'
Harmaria	20°55' : 70°50'
Ingorala	21°13'36" : 71°14'36"
Paula hill	Δ 1,113
Jikiali	21°15'36" : 71°15'26"
Kotada	21°05' : 71°55'
<i>Banaskantha district.</i>	
Pasaval	24°28'20" : 72°22'36"
Diwaunia	24°22' : 72°44'
Khunia	24°22'30" : 72°41'00"
Karamudi	24°22'00" : 72°46'30"
Palanpur	24°10' : 72°25'
Gangu	24°22'00" : 72°39'40"
Bhaldi	24°28' : 72°23'
Gangavada	24°28'00" : 72°26'30"
Kotada	24°26' : 72°23'
Bhilachal	24°26'10" : 72°26'00"
Hadmatiya	24°25'00" : 72°27'30"
Piloti	24°32' : 72°28'

LOCALITY INDEX—*contd.*

<i>Baroda district.</i>	<i>Latitude—Longitude :</i>
Chuchupura	22°13' : 73°38'
Narukot	22°23' : 73°42'
Ghanta	22°28' : 73°40'
Nathpura	22°29' : 73°42'
Jair	22°22' : 74°02'
Rajpur	22°19' : 74°24'
Mithibor	22°30' : 74°00'
Chetapur	22°25' : 73°50'
Malu	22°20' : 73°55'
Bhilpur	22°20' : 73°55'

Bhavnagar district.

Piperla	21°40' : 71°54'
Sansora	21°44' : 71°48'
Chogat	21°49' : 71°55'
Methla	21°10' : 72°04'
Naip	21°06' : 71°56'
Gujarda	21°02' : 71°47'
Gondal	21°55' : 70°45'
Patanwao	21°35' : 70°15'
Upleta	21°40' : 70°15'
Paneli	21°50' : 70°05'
Bhavnagar	21°47' : 72°09'
Janijhmer	21°11' : 73°06'
Modhuban	21°10' : 72°05'
Dial	21°08' : 72°59'
Sanosra	21°40' : 71°45'
Abhramपुरa	21°10' : 71°15'

Broach district

Vanji	21°54' : 73°48'
Shir	21°54' : 73°49'
Goraa	21°52' : 73°41'

LOCALITY INDEX—*contd.*

<i>Broach district —contd.</i>		<i>Latitude—Longitude :</i>
Bhilod		21°26' : 73°12'
Bharan		21°30' : 73°02'
Kondh		21°35' : 73°05'
Ambakhedi		21°44' : 73°18'
Rakhaskundi		21°38' : 73°17'
Bhilvasi		21°15' : 73°39'
Tejpur		21°46' : 73°17'
Survani		21°53' : 73°48'
Limkhetar		21°55' : 73°51'
Sajanava		21°42' : 73°20'
Amatyhar		21°42' : 73°14'
Dali		21°47' : 73°20'
Bamambalia		21°48' : 73°22'
Khadagda		21°55' : 73°42'
<i>Dangs district.</i>		
Chirchinagotha		20°48' : 73°33'
Satpuriya		20°48' : 73°31'
Dhadra		20°49' : 73°33'
<i>Junagadh district.</i>		
Chorvad Road Railway Station		21°03' : 70°20'
Kiuderwa		21°00'00" : 70°21'30"
Adri Road Railway Station		20°59' : 70°22'
Dari		20°57' : 70°22'
Veraval		20°54' : 70°25'
Savni		20°57'30" : 70°29'00"
Patau		20°53' : 70°27'
Lati		20°52' : 70°29'
Gorakhmudi		20°54' : 70°35'
Prachi		20°55' : 70°39'
Sutrapara		20°51'00" : 70°31'30"
Warodra		20°49' : 70°34'

LOCALITY INDEX—*contd.*

<i>Junagadh district—contd.</i>	<i>Latitude—Longitude</i>
Rajpura	20°46' : 71°07'
Babarkot	21°52' : 71°24'
Mitiala	20°53' : 70°35'
Jafrabad	20°51' : 71°22'
Vadhera	20°53' : 71°19'
Masankodi	20°51' : 70°33'
Vedera	20°53' : 71°15'
Rohisa village	20°50' : 71°16'
Dharabunder	20°49' : 71°14'
Khajndara	20°47' : 71°07'
Mangrol	21°08' : 70°07'
Samadhiala	21°00' : 70°15'
Talala	21°00' : 70°30'
Mangrol	21°05' : 70°05'
Maktumpur	21°08' : 70°06'
Lohij	21°10' : 70°04'
Sil	21°11' : 70°03'
Madhabpur	21°15' : 70°01'
Porbandar	21°39' : 69°35'
Gosa	21°31' : 69°44'
Aditiyana	21°43' : 69°42'
Ranpur	21°50' : 69°41'
Ranawao	21°40' : 69°40'
Kutiyana	21°38' : 69°59'
Godhagra	21°15' : 71°26'
Ramgadh	21°14'45" : 71°24'30"
Sarakaria	21°00' : 71°05'
Itvaya	20°56'30" : 71°00'30"
Kontala	21°02' : 71°12'
Kharadhar	21°05'30" : 71°14'45"
Khambha	21°09'00" : 71°17'30"
Malia	21°05' : 70°15'

LOCALITY INDEX—*contd.*

<i>Kaira district.</i>	<i>Latitude—Longitude</i>
Gundela	23°06' : 73°22'
Balasinor	22°58' : 73°20'
Haria	22°51' : 73°21'
Chaklasi tank	22°58' : 73°20'
Kunjra	22°58' : 72°18'
Bhejia Kiari	23°01' : 73°19'
Bir	22°59' : 73°18'
<i>Kutch district.</i>	
Lakhpat	23°50' : 68°45'
Gehuneri	23°48' : 68°51'
Adesar	23°33' : 71°02'
Adkudi	23°24' : 70°35'
Badargari	23°28' : 70°41'
Chitrov	23°24' : 70°44'
Umarsar	23°45' : 68°54'
Jhuradome	23°26' : 69°38'
Keera dome	23°55' : 69°17'
Lakhpat	23°35' : 71°00'
Khavada mahal	23°50' : 69°46'
Chodsise	23°06' : 69°23'
<i>Naunagar district</i>	
Naunagar	20°40' : 73°20'
Rinjpur	22°05' : 69°55'
Lalpur	22°10' : 69°55'
Khirasra	22°10' : 69°55'
Narmana	22°05' : 70°10'
Jamnagar	22°25' : 70°00'
Sarwania	22°10' : 70°25'
Katkola	21°50' : 69°50'
Sarodar	22°00' : 70°10'
Dheraji	21°40' : 70°25'

LOCALITY INDEX—*concl'd.*

Naunagar district—contd.

Latitude—Longitude :

Darwi	22°00' : 70°25'
Kondorna	21°35' : 69°50'
Khijaria	22°05' : 70°25'
Jasapur	21°50' : 69°35'
Mahadevia	22°10' : 69°15'
Rasangpur	22°15' : 69°45'
Pipli	22°20' : 69°55'
Sapur	20°50' : 70°55'
Navugam	23°40' : 73°20'
Rangpur	22°20' : 71°55'
Modpur	23°55' : 74°10'
Sidsara	22°05' : 69°25'

Panchmahals district.

[illegible]

Sabarkantha district.

[illegible]

Surat district.

Tadkeshwar **21°23':73°06'**

HIMACHAL PRADESH

Bilaspur district

P. C. Sogani (Krishnan, 1958) reports the occurrence of limestone (both dolomitic and non-dolomitic) among the Pre-Tertiary rocks. The pink and the greyish varieties occur in the eastern parts of the area.

The following table gives the chemical analyses of a few samples of limestone :—

Locality	SiO ₂ %	Al ₂ O ₃ † Fe ₂ O ₃ %	MgO %	CaO %	Loss on ignition %	Total
1. 300 m. east of Jamthal.	7.81	2.02	1.65	47.60	39.63	98.73
2. Aur or Gagat Hill (-3106).	7.40	2.51	1.44	47.09	40.20	98.64
3. 150 m. N.W. of Chhabawan.	7.22	2.01	4.34	44.50	40.60	98.67
4. 400 m. south of Daroda.	14.28	5.01	4.28	39.01	35.65	98.73
5. 150 m. N.W. of Chhabawan.	11.01	2.01	1.28	46.29	37.77	98.45

From the analyses, Sogani concluded that the limestones of the types of 1, 2 and 4 are suitable for cement manufacture. The other two varieties may find use after suitable blending with better grade material.

There are two small deposits of calc-tufa at Lathwin (31°31' : 76°41') and near Thakurdwara (31°26' : 76°41').

Mahasu district

B. N. Raina (Krisnan, 1954) reports the occurrence of limestone deposits at Khadli and Kakarhatti, part of which may be useful for cement manufacture and other purposes. Some of the Krol limestones at Solan were also sampled for chemical analysis.

Outcrops of Shali limestone occur at the following places :—

- (1) Baraihua (31°12' : 77°20'),
- (2) Tatapani (31°15' : 77°51'),
- (3) Alsindi,
- (4) Kot and Chajahi,
- (5) Kathnol,
- (6) Chaba and Seoni,
- (7) About 105 km. N.W. of Arki and
- (8) Kakarhatti (30°6' : 76°58')

Mandi district

R.N. Kacker reports that a few samples of Krol limestone (calcareous series collected from near Pungh ($31^{\circ}30' : 76^{\circ}53'$), Dhanesri ($31^{\circ}33' : 76^{\circ}53'$) and Jarel ($31^{\circ}27' : 76^{\circ}51'$) give on an average 46.6% of CaO and 0.93% of MgO. The samples from near Talwana ($31^{\circ}25' : 76^{\circ}52'$) analysed 38.4% of CaO and 1.86% of MgO.

One 30 m. thick, thinly bedded Pre-Tertiary limestone band, suitable for Portland and low heat cement occurs near Larji ($31^{\circ}43' : 77^{\circ}13'$). Reserves of limestone have been estimated at about 100 million tonnes containing 48% of CaO and about 9% of SiO_2 .

Sirmur district

Mukti Nath (West, 1950) carried out a detailed investigation of the limestone deposits of Sataun ($30^{\circ}34' : 77^{\circ}38'$) occurring along the Giri river between Bhatrog ($30^{\circ}33' : 77^{\circ}40'$) and Kyari ($30^{\circ}34' : 77^{\circ}35'$) over a distance of about ten kilometers.

The limestone deposits lying to the south of the Giri river were examined by A.S. Dass and the possible reserve estimated are of the order of 100 million tonnes.

The Sataun limestone overlies the Nahans and is light grey in colour and fine-grained in texture. It is suitable for the manufacture of Portland cement. Ramifying veins of calcite are common in the limestone between Bhatrog ($30^{\circ}33' : 77^{\circ}40'$) and Sataun.

Twenty-five samples after analysis show insolubles below 5%. The variation in chemical composition of these 13 samples is given below :—

Insolubles	R_2O_3	CaO	MgO	Loss on ignition
2.94-4.94%	0.75-3.00%	49.82-52.14%	Trace-2.26%	40.70-42.22%

Seven samples show insolubles ranging between 5 and 10%. The variation in the chemical composition of these seven samples is given below :—

Insolubles	R_2O_3	CaO	MgO	Loss on ignition
5.98-9.62%	1.22-2.70%	48.93-50.10%	Trace-2.61%	38.00-40.44%

Five samples show insolubles more than 10%.

The average insolubles for 25 samples of Sataun limestone is 6.92%.

Four samples show only a trace of magnesia; 16 samples show magnesia below 1%; two samples between 1 and 2%; two samples between 2 and 3% and only one sample shows magnesia above 3%. The average magnesia content for 25 samples is 0.97%.

The lime content varies between 38 and 54% but the average lime for 5 samples is 49.51%, equivalent to 88.4% of CaCO_3 .

The average content of R_2O_3 for 25 samples is 2.13%.

Reserves :

(1) Sataun (30°34' : 77°38') to Bhatrog (30°33' : 77°40').

Assuming the average thickness of the limestone band as 60m. the reserves of limestone in this portion have been estimated at nearly 15 million tonnes.

(2) Sataun to Nadi (30°34' : 77°35').

Assuming the average thickness of the limestone band as 60m. the reserve have been estimated at 5.6 million tonnes.

(3) Nadi to Dadua (30°34' : 77°35').

Assuming the average thickness as 30m. the reserves of limestone have been estimated at 75.5 million tonnes.

(4) Dadua to Kyari (30°34' : 77°36').

This belt of limestone is 2.4 km. long and is 60 m. thick (average). The reserves amount to about 45 million tonnes.

The total quantity of limestone available in this area is about 140 million tonnes.

Overlying the Sataun limestone, occur two bands of Mandhali limestone which crop out at the Bhitanka *nala* and between Sataun and Poka (30°33' 77°40'). The formations consist of alternations of shaly limestone and calcareous slates. Some bands are siliceous. The range in chemical composition of five analyses is given below :—

Insolubles %	R ₂ O ₃ %	CaO %	MgO %	Loss on ignition %
9.28—32.90	2.00—12.67	30.72—44.97	0.44—2.81	26.72—35.63.

G. N. Dutt (Krishnan, 1954) found good quality limestones in the Jal Muse ka Khala stream section north of Barthal village (30°33' : 77°26', 53 F/6). The limestone is exposed over a length of about 1130 m. and is 7.6 to 45.7 m. thick. Limestone in the centre of the band grades rapidly into dolomite. The total reserves, considering the average thickness as 34 m. and workable depth to 61 m. from the surfaces, are about 3.7 million tonnes. Another thin band of limestone, the thickness of which varies between 2 and 7.6 m. has been recorded about 275 m. north of Tina (30°33' : 77°24', 53 F/6).

A few kilometres further east, Dutt encountered a thick run of limestone, suitable for the manufacture of normal Portland cement at Kansar (30°33' : 77°29', 53 F/6). The western extremity of the band starts as a thin bed on the eastern slopes above the Shila ka Khal. Further east on the main ridge the thickness of the band rapidly increases to about 215 m. near Kansar. An outcrop of the limestone measuring 274.5 m. × 15.2 m. occurs about one kilometre due west of the village. The total reserves to a depth of about 91.5 m. is of the order of 17 million tonnes.

Similar limestone also occurs to the S.E. of Khair (30°34' : 77°31'). The MgO is about 1.2%. The total reserve is about 7.5 million tonnes.

North of Bakan ($30^{\circ}34' : 77^{\circ}32'$) three bands of limestones, 9 m., 3 m. and 7.6 m. respectively are exposed from south to north, interbedded with slates. As the bands are impersistent, the reserves are likely to be limited.

Mukti Nath (West, 1950) records the occurrence of high grade crystalline limestone (marble) at Naura ($30^{\circ}49' : 77^{\circ}25'30''$), Bhangari ($30^{\circ}47' : 77^{\circ}24'$) and Jarag ($30^{\circ}50' : 77^{\circ}21'$). The limestone is medium to coarse-grained, and white in colour and occurs in association with the garnetiferous mica-schists of the Jutogh series. Near Hotna ($30^{\circ}49' : 77^{\circ}27'$) the limestone is very coarse and friable. Between Olana ($30^{\circ}49' : 77^{\circ}26'$) and Deona ($30^{\circ}48' : 77^{\circ}26'$), there are isolated outcrops of limestone.

The limestone beds at Naura and Bhangari are traceable for a distance of 10 to 11 km. each, with a thickness varying from 15 to 61m. The reserves of limestone at Naura have been estimated at 17 million tonnes. The variation in the chemical composition of samples from Naura limestone is as follows :—

SiO ₂ %	R ₂ O ₃ %	CaO %	MgO %	SO ₃ %	Loss on ignition %
0.99-3.34	0.60-0.85	52.25-54.25	0.87-2.18	Trace	41.68-42.92

Bhangari deposit :—The limestone band extends for 10 km. from Bhangari ($30^{\circ}47' : 77^{\circ}24'$) to Chinar ($30^{\circ}46' : 77^{\circ}29'$). The limestone is again traceable eastwards through Gandhauri ($30^{\circ}47' : 77^{\circ}27'$). Kotli ($30^{\circ}47' : 77^{\circ}28'$), Lorana ($30^{\circ}46' : 77^{\circ}28'$) and Chinar ($30^{\circ}46' : 77^{\circ}29'$). The quality and quantity of the limestone have not been investigated in detail.

The results of chemical analyses of three samples are given below :—

SiO ₂ %	R ₂ O ₃ %	CaO %	MgO %	SO ₃ %	Loss on ignition %
1.94	2.75	32.13	0.83	Trace	41.72
2.28	1.15	53.38	1.08	Trace	42.28
2.14	0.80	53.48	1.23	Trace	41.98

Jarag deposit.—From the hill south of Jarag ($30^{\circ}50' : 77^{\circ}22'$), the limestone extends for a distance of 120 to 150 m. in a northerly direction. The thickness of the limestone at Jarag is 15 m. At Sarajon ($30^{\circ}50' : 77^{\circ}22'$) a limestone exposure is traceable for 60 to 90 m. The results of three chemical analyses of this limestone are given below :—

SiO ₂ %	R ₂ O ₃ %	CaO %	MgO %	SO ₃ %	Loss on ignition %
5.36	1.16	50.47	1.93	Trace	40.76
3.76	0.84	52.77	0.94	Trace	41.34
1.50	0.50	54.09	1.12	Trace	42.26

Calcareous Tufa :

J. P. Srivastava (1953) reports a small deposit of calcareous tufa in Jabbalgarh near Mahan. An occurrence of the calcareous tufa has been reported from Shatdhara (30°52' : 77°12').

REFERENCES

- Krishnan, M.S., 1953.—General Report for 1953. *Rec. Geol. Surv. Ind.* Vol. 87, pt. I, p. 110-111.
- , 1954.—General Report for 1951. *Rec. Geol. Surv. Ind.* Vol. 85, pt. I, p. 70-71.
- Muktimath., 1949.—A note on certain high grade limestones (marble) in Sirmur district, Himachal Pradesh. G. S. I. Report (Unpublished).
- Roy, B. C., 1962.—General Report for 1958. *Rec. Geol. Surv. Ind.* Vol. 95, pt. I, p. 45.
- , 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.* Vol. 95, pt. I.
- West, W. D. 1950.—General Report for 1949. *Rec. Geol. Surv. Ind.* Vol. 83, pt. I, p. 140-141.

LOCALITY INDEX

Bi'aspur district—

Latitude—Longitude

Lathwin	31°31' : 76°41'
Thakurdwara	31°26' : 76°31'

Mahasu district—

Baraihua	31°12' : 77°20'
Tatapani	31°15' : 77°31'
Aisindhi	31°15' : 77°05'
Chaba	31°10' : 77°10'

Mandi district—

Pungh	31°30' : 76°53'
Dhanesri	31°33' : 76°53'
Jarel	31°27' : 76°51'
Tarwi Talwana	31°23' : 76°52'
Largi	31°43' : 77°13'

Sirmur district—

Sataun	30°34' : 77°38'30"
Bhatrog	30°33' : 77°40'
Kyari	30°34'00" : 77°34'30"
Nadi to Dadun	30°34'00" : 77°35'30"
Barthol	30°33' : 77°26'
Tina	30°33' : 77°24'
Kansar	30°33' : 77°29'
Bakan	30°34' : 77°32'
Naura	30°49'00" : 77°25'30"
Bhangari	30°47'00" : 77°24'30"
Jarag	30°50'00" : 70°21'30"
Hotua	30°48'30" : 77°27'
Olana	30°48'30" : 77°26'

LOCALITY INDEX—concl.

Sirmur district—concl.

Latitude—Longitude

Deoua	30°48' : 77°26'
Bhaugri	30°47'00" : 77°24'30"
Chinar	30°46'30" : 77°29'30"
Gaudhauri	30°47'00" : 77°29'30"
Kotli	30°47'00" : 77°27'30"
Lorana	30°46'00" : 77°28'30"
Jargg	30°50'00" : 77°21'30"
Sarajon	30°50' : 70°22'
Shatdhara	30°52' : 77°12'

JAMMU AND KASHMIR

Anantnag district

Anantnag (33°44' : 75°10').—G. H. S. V. Prasada Rao (Roy, 1962) reported an Upper Trias limestone band at Anantnag which is 3.2 km. long and has a strike N30°W—S30°E with a dip of 25° towards N60°E. A representative sample shows CaO-24.22%, MgO-8.3% and Insolubles-39.36%.

Achhibal (33°41' : 75°14').—According to G. H. S. V. Prasada Rao (Roy, 1962), the Upper Trias limestone band extends S. S. E. from Achhibal for about 6.4 km. and has a strike N30°W—S30°E with a dip of 30° towards N60°E. There is another 180 m. thick limestone band which is suitable for the manufacture of cement. The average composition of this limestone band (6 analyses) is CaO-53%, MgO-2.3% and the Insoluble is less than 1%. The reserves of this 180 m. thick limestone band have been estimated at 22 million tonnes. The total thickness of the limestone bands sampled is 159 m., out of which five bands of total thickness of about 150 m. contain more than 46%—CaO of and less than 5% Insolubles and MgO.

Bawan (33°46' : 75°13').—According to G. H. S. V. Prasada Rao (Roy 1962), thick-bedded limestones crop out about 800 m. north of Bawan along the escarpment. East of Bawan the limestone bands crop out northwards continuously for 800 m. and discontinuously towards the south. The limestones strike north-south and the dip is 22° eastward. There is another 100 m. thick limestone zone suitable for the manufacture of cement. The average of four analyses show CaO-54%, MgO-0.70% and Insolubles-2.2%. The range in variation of chemical composition of eight samples of the limestone is as follows :—

CaO	MgO	Calculated insolubles
28.48—55.8%	0.17—2.83%	Trace—43.18%

The total thickness of the limestone bands sampled is about 170 m. Out of which three bands of thickness 72.7 m. contain more than 46% CaO, and combined at less than 5% Insolubles and MgO.

The reserves of this limestone band have been estimated at 24 million tonnes down to a depth of 60 m.

Pahalgam (34°1' : 75°19').—According to G. H. S. V. Prasada Rao (Roy, 1962), about 3.2 km. N.E. of Pahalgam, the strike of the limestone bands is N.E.—S.W. and the dip is 18° towards N.W. The range in variation in chemical composition of six samples of this limestone is as follows :—

CaO %	MgO %	Calculated insolubles %
35.36—52.50	1.81—7.64	Trace—10.79

The total thickness of the limestone bands sampled is about 67 m. out of which two bands of total thickness of 58.4 m. contain more than 46% of CaO, less than 5% of Insolubles and MgO.

Verinag (33°31' : 75°15').—According to M. M. Nanda (Roy, 1962), the limestone bands occurring here are 25 km. long and 200 m. broad and form part of the major limestone occurrences north of the Panjal range. The general strike of the limestone beds is N.W.—S.E. and the dip is 50° towards S.W. The limestones are compact and massive. The variation in chemical composition of 23 samples of limestone from this area is as follows :—

CaO	MgO
39.27—53.71%	0.14—9.47%

(Only three samples have more than 5% MgO)

The analyses indicate that the limestone deposits are suitable for cement manufacture. According to Nanda, the reserves of the limestone, calculated to a depth of 60.9 m. are about 20 million tonnes of which the workable reserves would be about 13 million tonnes.

Doru (33°35' : 75°14').—According to G. H. S. V. Prasada Rao (Roy, 1962), the limestone bands starts from Lukabawan (33°38' : 75°10') and extends in a S.W. direction for about 16 km. The general strike of the Doru-Zamalgam (33°35' : 75°15') limestone band is N60°W—S60°E and the dip varies from 60° to 70° towards S30°W. Chip sampling of the limestone bands at Doru and Zamalgam revealed a 300 m. wide zone suitable for the manufacture of cement in the lower reaches of a ridge and also a few thin dolomitic limestone bands.

Out of 33 chip samples of limestone analysed from Doru, 23 had insolubles less than 5%. The variation in chemical composition of these 23 analyses is given below :—

Insolubles	CaO	MgO
Trace—4.42%	43.70—53.60%	0.58—6.82%

The variation in chemical composition of the rest ten analyses is given below :—

Insolubles	CaO	MgO
5.01—28.93%	38.00—51.90%	0.65—7.16%

The variation in chemical composition of 15 groove samples of limestone from Doru is given below :—

CaO	MgO
34.23—53.08%	Trace—15.56%

(Only three samples analyse at more than 10% of MgO)

The range in variation in chemical composition of 16 chip samples of limestone from Zamalgam is as follows :—

CaO %	MgO %	Insolubles %
40.72—57.14	1.00—3.00	1.38—11.30

(Eight samples have less than 5% insolubles)

The variation in chemical composition of 40 groove samples from the ridge between Doru and Tserkar is as follows :—

CaO %	MgO %
32.84—53.77	0.63—17.01

(Nine samples analysed at more than 10% MgO)

Reserves.—According to Prasada Rao, the reserves of limestone with 52% of CaO at the ridge near Doru have been estimated at 5.9 million tonnes down to a depth of 60 m. and the reserves of the limestone with 46% CaO have been estimated at 2.5 million tonnes.

The reserves of limestone on the ridge between Doru and Tserkar with 52.4% of CaO are estimated at one million tonnes and those with 45.5% of CaO are 0.7 million tonnes down to a depth of 60 m. There is also one million tonnes of limestone with 49.6% CaO near the top of the ridge.

The details of the reserves at Tserkar are given below (down to a depth of 60 m.) :—

2.43 million tonnes of limestone with 52.9% of CaO

0.5 million tonnes of limestone with 43.4% of CaO

1.52 million tonnes of limestone with 51.2% of CaO

1.82 million tonnes of limestone with 44.5% of CaO

After suitable blending the total reserves of limestone will be 6.27 million tonnes down to a depth of 60 m. with 49% of CaO.

The chemical analyses show that the limestone deposits at Doru, Achchibal and Bawan of Anantanag district are extensive and suitable for the manufacture of cement.

Baramula district.

Bandipura deposits (34°25' : 74°39').—According to G. H. S. V. Prasada Rao (Roy, 1962) shaly limestone alternating with shales occurs in the ridge with peaks Δ 6,365 (34°25' : 74°39'), Δ 7,702 (34°26' : 74°42'). The CaO content of the shaly limestones from north of Erin (34°25' : 74°39') varies from 23% to 50 % (16 analyses) and the MgO from 0.4% to 1.2% in the six samples analysed. Above the shaly limestone hands, there is a dolomitic band 55 m. thick with MgO varying from 5% to 17%. Above this, there is a 12 m. thick cement grade limestone band followed by a 12 m. thick shaly limestone band. Over this shaly limestone band there is a 24 m. thick bluish grey limestone band of

cement grade with an average CaO content of 51% (4 analyses) and MgO 0.6%. Overlying this band, there is a 90 m. thick dolomitic band with MgO varying from 10 to 19%. The range in variation of chemical composition of the massive bluish grey limestone is as follows :—

CaO	MgO
30.60—52.36%	0.94—19.42%

The limestone deposits occurring between Jakia (34°17' : 74°4') and Aham Shariff (34°28' : 74°40') extend over an areal distance of about 18 km. The limestone is generally dark grey to bluish grey in colour and is massive and thick-bedded. The strike of the limestone deposit varies from E. N. E. to S. S. E. with a northerly dip varying from 30° to 60°.

The variations in chemical composition of the limestone from different localities are given below :—

Kunan Babagund (34°25' : 74°40')	(32 analyses)
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CaO	MgO
21.86—49.98%	0.32—1.33%

Naidapal (34°24' : 74°39')	(18 analyses)
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33.32—50.54%	0.45—8.26%
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Madar (34°25' : 74°39')	(56 analyses)
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13.51—49.95%	8.22—1.34%
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14 samples contain more than 40% CaO.

East of Sonarwain (34°27' : 74°39')	(13 analyses)
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CaO	MgO
20.04—46.13%	0.53—1.19%

Manasbal (34°15' : 74°41').—According to G. H. S. V. Prasada Rao (Roy, 1962), the limestone deposits in the N. N. E. of Δ 6,272 strike N70°W—S70°E and the dip is 65° towards S20°W. A 200 m. long limestone band from the Manasbal village analysed as follows (11 analyses) :—

CaO	MgO
49 to 52%	Less than 1%

Assuming that these bands, which are suitable for the manufacture of cement, continue for 480 m. along the strike, the probable reserves have been estimated at 3.45 million tonnes.

The limestone band in the ridge east of the Manasbal lake has a strike N70°W—S70°E and the dip is 40° towards S20°W. At the base of the hill there is a shaly limestone band with CaO content varying from 22 to 50% (7 analyses) and the MgO content from 0.2 to 1%. Above this, three dolomitic bands with MgO content from 8% to 14% (10 analyses) alternate with two low magnesia limestone bands of 46 and 42 m. thickness whose CaO content varies from 38 to 49% and MgO, from 0.5 to 2% (7 analyses).

Biru (34°1': 74°36').—According to G. H. S. V. Prasada Rao (Roy, 1962), the strike of the bedding of the limestone band is N24°W.—S24°E. and the dip is 65° towards N66°E. (at places). At the easternmost extremity of this outcrop, there is another 70 m. thick limestone band suitable for the manufacture of cement. The average of four analyses show CaO content at 51% and MgO at 2.5%. The variation in chemical composition of 6 chip samples of limestone from Biru is as follows :

CaO	MgO	Calculated insolubles
39.00—52.06%	2.07—3.31%	2.53-24.76%
(three samples analysed less than 5% Insolubles)		

The total thickness of the limestone bands analysed is 99 m., out of which four bands of total thickness of 69.5 m. contain more than 46% of CaO ; the Insolubles and MgO content are less than 5%.

The probable reserves have been estimated at 1.2 million tonnes.

Zachildor (34°24' : 74°12').—According to G. H. S. V. Prasada Rao (Roy, 1962), the strike of the limestone band just north of Zachildor is N60°E.-S60°W. and the dip is 49° towards N30°W. The maximum width of the fine limestone bands is 17m. and the maximum length is 90 m. The average of five analyses of representative specimens of these bands show CaO-50%, MgO-2.2% and Insolubles, etc.-5.3%. The limestone bands are thin and impersistent and the reserves are not appreciable. The variation in chemical composition of five chip samples of limestone from this area is as follows :—

CaO	MgO	Calculated Insolubles, etc.
48.33—52.88%	1.30—3.11%	Trace—9.45%

The total thickness of the limestone bands analysed is 45.7 m. out of which two bands of total thickness of 20.38 m. contain more than 6% CaO ; Insolubles and MgO are less than 5%.

The reserves of cement grade limestone have been estimated to 20 million tonnes down to a depth of 60 m. at the following places :—

Kunan Baba Gund	4.75 million tonnes
Naidahal	3 million tonnes
Madar	1 million tonne
Erin (34°25' : 74°39')	3.5 million tonnes
Ajas (34°20' : 74°41')	4.5 million tonnes
Gundi-Sunderket (34°18' : 74°39'30")	3.2 million tonnes

Poonch district

Near Joka, foraminiferal limestone interbedded with Murree sandstones extend for over 32 km. with a maximum thickness of 90 m. A similar limestone deposit occurs between Sarl and Salamabad. The limestone is dense, fine-grained and contains high lime.

Srinagar district

Sonamarg (34°18' : 75°18').—G. H. S. V. Prasada Rao (Roy, 1962), has reported many limestone bands north and south of the Sind river. The variation in chemical composition of four chip samples is given below :—

Insolubles %	R ₂ O ₃ %	CaO %	MgO %	Loss on ignition %
0.24—0.68	0.40—0.70	48.71—51.65	3.07—5.32	43.86—44.36

The general strike of the six major siliceous limestone bands between Baltal and Zojila is N.W.-S.E. and the dip is 47° towards N.E. The variation in chemical composition of four samples from these bands is as follows :—

CaO	MgO	Calculated insolubles
43.7—49.87%	2.85—3.76%	4.94—14.06%

The total thickness of the limestone bands analysed from Baltal-Zojila area is 51.7 m., out of which two bands of total thickness of 3.9 m. contain more than 46% of CaO ; the Insolubles and MgO are less than 5%.

Vihī valley.—According to G. H. S. V. Prasada Rao (Roy, 1962), the strike of the limestone band occurring between Wuyan (34°1' : 74°58') and Khrew (34°1' : 75°0') is N20°E.-S20°W. and the dip is 60° towards N70°W. The average CaO content is 35%, MgO is 2.3% and Insolubles etc., are 29%. A 18 m. thick cement grade limestone band with a CaO content of 50% extends for 800 m. west of the above deposit.

Another 80 m. thick limestone band suitable for the manufacture of cement is traced for 800 m. along the strike. The average of five analyses show CaO-48 % and MgO-2.2 %. At Khrew, the strike of the limestone bands is N 10° W—S 10°E. and the dip is 49° towards N 80° E. The average composition of this 26 m. thick cement grade limestone band is CaO-49 %, MgO-1.25 % and Insolubles-9.87 %. This band extends for about 1.5 km.

The total thickness of the limestone bands sampled is 309 m. out of which three bands of total thickness of 46.6 m. contain more than 46 % of CaO ; the Insolubles and MgO content are less than 5 %.

Reserves.—Assuming the 80 m. thick limestone band at Wuyan to extend strikewise for 800 m., the probable reserves have been estimated at 4.5 million tonnes down to a depth of 30 m. Further assuming the 26 m. thick cement grade limestone band at Khrew to extend for 1.6 km., the probable reserves have been estimated at 3 million tonnes down to a depth of 30 m.

Udhampur district

Jangalgali area (33°02' : 75°02') :—According to B. S. Srivastava (Roy, 1962), the limestone is the oldest formation in the area. It is fine-grained, dense and hard and has a strike N.W.—S.E. with dips between 50° and 75° in the N.E. direction. Chert bands range in thickness upto 15 cm. From the analyses of 169 samples of limestone in this area, it is found that CaO varies between 14.45 and 31.05 % and MgO between 10.34 and 34.04 %. Because of low percentage of CaO and high content of MgO this limestone is not suitable for the manufacture of Portland cement.

The reserves have been estimated at 14 million tonnes down to a depth of 15 m.

Limestone deposits between Muttal (32°59' : 75°02') and Riase (33°02' : 74°55').—According to M. L. Bhat and M. M. Nanda (Roy, 1962), a limestone belt, 32 km. long lies between Muttal and Salal (33°10' : 74°49') in the Udhampur district. The area is covered by the Great Limestone series. The general strike of the limestone bed N.N.W. of Muttal is N75°W.-S 75°E, the dip being 52° due N15°E. Out of a total of 46 samples analysed from the Muttal area, 12 samples have less than 5% insolubles, 10 samples have insolubles ranging between 5% and 10% and the rest have insolubles above 10%. The overall variation in chemical composition of these samples is given below :—

CaO	MgO	Insolubles
21.87—30.25%	15.41—21.25%	1.06—36.64%

Katra (32°59' : 74°59')-Chimiara (33°02' : 74°55') area.—This area is also covered by the Great Limestone series. The general strike of limestone in the Katra area is N.W.-S.E. with dips of 50° to 60° due north-east. The variation in chemical composition of 31 samples of limestone, analysed from this sector, is as follows :—

CaO	MgO	Insolubles
18.33—28.73%	13.39—20.02%	5.10—35.12%

Bluish grey limestone occurring in the Anji (33°04' : 74°53')-Salal (33°10' : 74°49') sector have a strike varying from N15°W-S15°E with dips ranging from 50° to 78° due north. The variation in the chemical composition of 57 samples of limestone from this area is given below :—

CaO	MgO	Insolubles
20.30—37.24%	3.19—20.82%	1.28—31.50%

According to M. M. Nanda (Roy, 1962 b), a low magnesian horizon runs as a continuous band, varying in thickness from 15 to 90 m. in the 20 km. long Great Limestone belt from Salal (33°10' : 74°50') to Kanthan (33°10' : 74°52'), Sersandu (33°08' 30" : 74°53') and Rahot Kot (33°06' : 74°55'). The band is composed of thinbedded, dark blue limestone with chert stringers parallel to the bedding. It has been estimated that an *in situ* reserve of 10 million tonnes are present in the belt, presuming a workable depth of 15 m. only along the dip and assuming an average thickness of 15 m. Continuous channel sampling of the band has indicated that the limestone is suitable for cement provided silica can be removed by floatation or in some other suitable form of beneficiation. The CaO content varies from 19.60 to 30.39 % in the Kanthan section (as seen from 18 analyses). In the Sersandu section of the limestone belt, the CaO content varies from 15.07 to 51.06 % (66 analyses). In the Rahot Kot section, the CaO varies from 15.62 to 46.58 % (73 analyses).

The variation in chemical composition of 24 representative samples from the Great Limestone belt is given below :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
8.80—31.02%	0.24—3.14%	0.20—2.00%	26.28—51.08%	0.70—10.17%

Out of 24 analyses five samples analyse at less than 10 % SiO₂, 19 samples at less than 5 % MgO and 17 samples at more than 40 % CaO.

According to Nanda (Roy, 1964), the low magnesian horizon in the Sirban limestone runs continuously in the area west of the Cherab in the Udampur district with a thickness varying from 9 m. to 80 m. The variation in chemical composition of 53 samples from this area is as follows :—

CaO	MgO
39.86—52.27%	0.97—5.90%

The utilisation of the limestone from this band is dependent upon the reduction by floatation of the silica content. The reserves have been estimated at eight million tonnes.

The deposits of calc-tufa are widespread in Jammu and Kashmir particularly in the Udampur district, the important one being at Jib (32°55' : 75°3').

REFERENCES

- Bhat M.L. and Nanda M.M., 1958.—Preliminary report on the suitability of limestone deposits between Muttal and Riasi for the manufacture of Portland Cement G.S.I. Report (unpublished).
- Nanda M.M., 1959.—Report on the investigation of the "Great Limestone" for manufacture of Portland Cement. G.S.I. Report (unpublished).
- Nanda M.M., 1960.—Report on the preliminary investigation of the Riasi Sirbon Limestone inlier in the area west of Chenab river. G.S.I. Report (unpublished).
- Nanda M.M., 1957.—Report on the limestone deposits near Verinag, Anantnag districts, Kashmir. G.S.I. Report (unpublished).
- Rao, G.H.S.V.P., Srivastava, B.S. and Nanda M.M., 1958.—The limestone deposit of the Kashmir valley. G.S.I. Report (unpublished).
- Roy, B.C., 1962.—General Report for 1956.—*Rec. Geol. Surv. Ind.* Vol. 91, pt. I, p. 78-81
- , 1962.—General Report for 1957. *Rec. Geol. Surv. Ind.* Vol. 92, pt. I, p. 43-44
- , 1962.—General Report for 1958. *Rec. Geol. Surv. Ind.* Vol. 93, pt. I, p. 43
- , 1962.—General Report for 1959. *Rec. Geol. Surv. Ind.* Vol. 94, pt. I, p. 74
- , 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.* Vol. 95, pt. I.

LOCALITY INDEX

Anantnag district—

Latitude—Longitude:

Anantnag	33°44'	: 75°10'
Achhibal	33°41'	: 75°14'
Bawan	33°46'	: 75°13'
Pahlgam	34°01'	: 75°19'
Verinag	33°30'30"	: 75°15'00"
Doru	33°55'	: 75°14'
Lakabewan	33°38'	: 75°10'
Zamalgam	33°35'	: 75°15'
Manasbal	34°10'	: 74°35'

Baramula district—

Bandipura	34°25'	: 74°39'
Peak 6365	34°25'	: 74°39'
Peak 7702	34°25'	: 74°42'
Erin	34°25'	: 74°39'
Jakia	34°17'20"	: 74°40'40"
Aham Shariff	34°28'	: 74°40'
Kunang Babagund	34°25'00"	: 74°40'50"
Naidapal	34°23'45"	: 74°39'30"
Madar	34°25'00"	: 74°39'30"
Sonarwain	34°27'	: 74°39'
Manasbal	34°15'	: 74°41'
Birk	34°01'	: 74°36'
Zachildor	34°24'	: 74°12'
Ajab	34°20'	: 74°41'
Gundi Sudarkut	34°18'	: 74°39'30"

Poonch district—

Salamabad	34°05'	: 74°00'
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LOCALITY INDEX—concd.

Srinagar district—

Latitude—Longitude

Sonamary	34°18' : 75°18'
Baltaf	34°15' : 75°25'
Wuyan	34°1' : 74°58'
Khrew	34°01' : 75°00'

Udhampur district—

Jangalgoli	33°02' : 75°02'
Muttal	32°59' : 75°02'
Riasi	33°02'30" : 74°55'30"
Salal	33°09'40" : 74°49'30"
Katra	32°59'15" : 75°59'15"
Chiminara	33°02' : 74°55'
Anji	33°04' : 74°53'
Salal	33°09'40" : 74°49'30"
Kanthan	33°10' : 74°52'
Sarbandu	33°08'30" : 74°53'30"
Rahot Kot	33°06'30" : 74°55'30"
Jib	32°55' : 75°03'

KERALA STATE

Cannanore district

Damodaran (Krishnan, 1954) recorded shelly limestone beds in the low lying *back-waters* close to the sea near Puthur ($12^{\circ}54' : 74^{\circ}58'$), Nileshtar ($12^{\circ}15' : 75^{\circ}8'$) and Cheruvathur ($12^{\circ}13' : 75^{\circ}9'$). The shelly layer occurs at a depth of one to four metres from the surface and varies in thickness from 15 cm. to 75 cm. These shell beds occur over a few hundred hectares and hence they are not large enough to be worked on a commercial scale.

Kottayam district

A large deposit of shelly limestone occurs within the Vembanad lake. The CaO content is 54.5% and SiO_2 0.5%. Poulouse (1963) estimated the reserves of shells over an area of 15 sq. km. in the Varikom and Pathiarmal areas in the Vembanad lake to be of the order of 2 to 2.5 million tonnes upto eight metres from the water level.

A.S. Narasimhan (Roy, 1964) investigated the reported occurrence on crystalline limestone around Munnar in Devikulam *taluk* where no deposit occurs except an occurrence of calc-gneiss within the Periyar Estate ($10^{\circ}5' : 77^{\circ}4'$). Small lenses of crystalline calcitic limestone, high in silica, are associated with quartz-felspar gneiss at Yella Palli Estate ($10^{\circ}8' : 70^{\circ}13'$). These are not of economic importance.

Kozhikode district

R. Thiagarajan (1957) reports the occurrence of shelly limestone in the backwaters of Korapuzha river north of Elattur ($11^{\circ}20' : 75^{\circ}44'$). The shell layer is about one metre thick and occurs over a length of 800m. The production is about three to five tonnes a day, and is used for lime burning. The occurrence is not of economic importance.

Palghat district

CRYSTALLINE LIMESTONE

Small, narrow, lenticular bands of crystalline limestone in intimate association with the calc-granulites are recorded north of Chavadipara by G. Mani (1961-62). The limestone is generally white in colour and medium-grained. Four such bands of crystalline limestone have been met with in the area mapped :—

(1) About 600 m. E.S.E. of Nettuvengai, a band of crystalline limestone trends $N75^{\circ}E$.— $S75^{\circ}W$. and dips 55° towards south. This band is about 50 m. long and five metres wide.

(2) About 1.2 km. E.S.E. of Chemmanthi Malai, a band of crystalline limestone trends N80°E.—S80°W. and dips 50° towards south. The band is about 45 m. long and about 20 m. wide.

(3) About 400 m. north of Pandaretu, a band of crystalline limestone trends N85°E.—S85°W. and dips 45° towards the south. The band is about 1,200 m. long and about 20 m. wide.

(4) A fourth band of crystalline limestone, about 15 m. long and about 8 m. wide, is noticed about 400 m. E.N.E. of Pandaretu. This band trends E.N.E.-W.S.W. and dips 50° towards S.S.E. The chemical analyses of limestone from bands No. 1 and 3 are as follows:—

Serial No.	Locality	CaO %	MgO %	R ₂ O ₃ %	SiO ₂ and Insolubles %
1.	From the band about 600 m. E.S.E. of Netuvengai.	43.67	—	1.35	18.91
2.	—	44.53	—	1.25	14.92
3.	From band about 400 m. north of Pandaretu.	44.7	—	1.0	14.53
4.	—	47.67	—	1.0	11.85
5.	—	45.9	—	1.1	11.56
6.	—	45.05	—	1.5	14.52

The magnesia content is found to be nil in all the analyses. The results of the analyses of the limestone reveal that the limestone is of cement grade.

Reserves.—The probable calculated reserves of limestone of these two deposits are 350,000 tonnes.

KANKAR

Small deposits of greyish white *kankar* occurs at the following places:—

(a) About 1.2 km. E.S.E. of Manchukunur; the *kankar* deposit is about 150 m. long and about 40 m. wide.

(b) In the Vartar river bed, N.E. of Muthukavundankulam, *kankar* capping is seen. The deposit is about 30 m. long and about 5 m. wide.

(c) Just north of Olalapadi, a deposit of *kankar* is observed which is about 200 m. long and about 20 m. wide at the surface.

The analyses of these *kankar* deposits are given below :—

Serial No.	Locality	CaO %	MgO %	P ₂ O ₅ %	SiO ₂ and Insolubles %
1.	About 1.2 km. E.S.E. of Manchukunnur.	43.47	—	2.25	15.52
2.	In the Varattar river bed, N.E. of Muthukanundankulam.	44.17	—	3.0	13.94
3.	North of Olalapadi .	40.63	—	2.85	17.6

In all the above places, the *kankar* is intimately admixed with soil.

In the Chittur *tahuk* of Palghat district, *kankar* and calc-tufa occur in Valiavalampathy, Ozhalapathy and Attampathy areas. The total extent of the area is 1011 hectares.

REFERENCES

- Krishnan, M.S., 1954.—General Report for 1952. *Rec. Geol. Surv. Ind.* Vol. 86, pt. I, p. 109.
- Mani, G., 1961-62.—Progress Report for 1961-62., *Geol. Surv. Ind.* (unpublished).
- Poullose, K.V., 1963.—Interim Report on the investigation of shell deposits of Vembanad lake, Kerala (unpublished) report of *Geol. Surv. Ind.*
- Roy, B.C., 1962.—General Report for 1958. *Rec. Geol. Surv. Ind.* Vol. 93, pt. I, p. 43.
- , 1964.—General Report for 1960-61. *Rec. Geol. Surv. Ind.* Vol. 95, pt. I.
- Thiagarajan, R., 1956-57.—Progress Report for 1956-57 (Unpublished).

LOCALITY INDEX

<i>Cannanore district—</i>	Latitude	Longitude
Puthur	12°34'	74°58'
Nileswar	12°15'	75°8'
Cheruvathur	12°13'	75°9'
<i>Kottayam district—</i>		
Periyar Estate	10°5'	77°4'
Palli Estate	10°8'	70°13'
<i>Kozhikode district—</i>		
Elattur	11°20'	75°44'
<i>Palghat district—</i>		
Chayadipara	10°50'	76°45'
Chammauthi Nalai	10°50'	76°45'

MADHYA PRADESH

Balaghat district

According to K. D. Shukla and M. R. Subramanyam (1958), the pink marble of the Lohangi stage forms a fairly large exposure, W.N.W. of Ramrama ($21^{\circ}52' : 79^{\circ}56'$) and west of the Sonawani ($21^{\circ}55' : 79^{\circ}54'$) road, over an area of about 610 m. long and 150 to 300 m. wide. There are other small patches of good pink marbles S. E. and east of Sirrajhari ($21^{\circ}53' : 79^{\circ}57'$). These are not of economic importance.

Bastar district

According to N.V.B.S. Dutt (1963), the middle unit of the Kanger limestone stage of the Indravati series consists of cement grade limestone with CaO 41-47%, MgO upto 4% (generally less than 1%) and SiO_2 13-22% (range of analyses of 184 samples). This unit is of bluish grey, cream, light grey to dark grey limestone, and ranges in thickness from 6m. to 52 m. Over a considerable part of the Kanger limestone belt, the middle cement grade limestones are covered by the upper siliceous limestones. In the following five areas, however, they are either exposed at the surface or have a soil cover of upto about six metres (Dutt, 1962) :—

1. Kadma Bade-Deerguda ($18^{\circ}58' : 81^{\circ}51'$) area,
2. Devarapal-Dhurvaras ($18^{\circ}57' : 81^{\circ}50'$) area,
3. The road-side area between the 28th and the 30th kilometer-stone on the Jagdalpur-Konta road, and from there for three kilometres to the E.S.E. along the Kanger river,
4. Majipal ($18^{\circ}53' : 81^{\circ}55'$)-Kotomsar ($18^{\circ}53' : 81^{\circ}55'$) area and
5. The area three kilometres S. E. of Kotomsar.

The probable reserves of the cement grade limestones in the five areas are of the order of 610 million tonnes.

Two of these areas, namely Kadma Bade-Deerguda and Devarapal-Dhurvaras areas, are within about five kilometres of the new railway line being laid down from Kottavalasa to Bachel (Bailadila). A third area is about 28 km. S. W. of Jagdalpur, between the roads to Konta and to Nagalsar ($18^{\circ}52' : 81^{\circ}59'$), and the other two areas are a few kilometres further to the S. E. on the road to Nagalsar.

In the search for flux grade limestones in Bastar district, the area 1.75 km. south of Devarapal and the area south of the Kanger river about one kilometre E.S.E. of the Kanger bridge ($18^{\circ}55' : 81^{\circ}53'$) deserve special attention (Dutt, 1964).

The detailed mapping and sampling of the limestone occurrences near the Kanger bridge and at Potonar ($19^{\circ}01' : 81^{\circ}53'$) and Baranji ($19^{\circ}09' : 81^{\circ}49'$) were later carried out by U. Prasad and S. Sen (Roy, 1964). The

investigation was continued in Kotomsar and Koblakur Dongri (18°56' : 81°52') areas along the Kanger river, by V. P. Sharma and N. S. Atram (1961-62).

† *Kanger area*.—About 65 samples of limestone analysed from Kanger area show the following variation in chemical composition—CaO 15.57—44.59% and MgO, 0.45—16.25%. Of the limestone bands sampled, those containing more than 42% CaO have an aggregate thickness of 60 m.

North-west of Koblakur Dongri, a 15—35 m. thick band of dark grey limestone located north of the Kanger river was traced over a distance of five kilometres to the north of Dhurvaras. The band has an average width of about 80 m. It dips gently (maximum dip 50°) to the N. E. The bands are differentiated on the basis of colour and other physical properties.

In the Majhar Dongri (18°54' : 81°54') area lying to the south of the Kanger river, the limestone deposit is much more extensive than the one north of the river. The width of outcrop of the deposit varies from 1 to 2 km. with maximum thickness of about 90 m. The limestone band is practically horizontal with a maximum dip of 5° to the south or south-east.

South-east of Kotomsar, a thick band of dark grey limestone was noticed over a strike length of more than 16 km. The limestone band has an outcrop width of about 1 to 2 km., with a maximum thickness of about 150 m. The limestone beds dip gently to the north, north-east and north-west with a maximum dip of 10°.

Potonar-Baranji area.—The limestone has an outcrop width of 80—100m. with a maximum thickness of about 25m. The beds dip at 3°—10° to the north or south. The estimated reserves of the cement grade limestone in the area are as follows :—

Locality	Length of outcrop (in metres)	Average thickness (in metres)	Indicated reserves (tonnes)
Baranji area	1,400	20	20,000,000
Sirsiguda-Banpuri area	3,000	10	25,000,000

The total estimated reserves of cement grade limestone in the different areas are about 632 million tonnes including 50 million tonnes of medium grade (CaO 35—40% and Insolubles 20—30%).

Sukma area.—According to N.V.B.S. Dutt (1963), the lower portion of the Kanger limestone, exposed in the Goral *nadi* to the S.W. of Kanjipani in the Sukma (18°23' : 81°40') area is of cement grade with CaO 44—47%, MgO less than 2% and Insolubles 11—18%. These limestones are bluish white or cream coloured. The grey upper limestone occurring to the east of Jagdalpur-Konta road are siliceous.

Bhopalpatnam area.—N.V.B.S. Dutt, S. Singh and U. Prasad (Roy, 1962b) investigated the cement grade limestones (CaO, 40 to 48%, MgO and R₂O₃ each less than 3% and Insolubles 3 to 27%) at Chinta Vagu and Timed (18°51' : 80°21'). The chemical analyses reveal that there are two bands of

1	2	3	4	5	6	7	8
Locality	Length of outcrop (in metres)	Average thickness (in metres)	Indicated reserves (tonnes)	Inferred reserves (tonnes)	Insolubles %	CaO %	MgO %
1. West of Kohlukur Dongri . . .	2,000	20	8,000,000	8,000,000	—	—	—
2. North of Dhurvaras Saijhodi area . . .	3,750	15	3,120,000	—	—	—	—
3. Majhar Dongri	3,000	40	360,000,000	—	—	22.96-44.28	0.36-6.69
4. Kotomsar (Phorl and Pusad Dongri) . . .	—	—	—	—	—	41.37-47.44	0.41-1.04
5. South-east of Kotomsar Gupansar Dongri (18°52' : 81°56') . . .	5,000	60	120,000,000	60,000,000	—	30.45-48.12	0.39-6.77
6. Jagaghatti area (18°51' : 81°59') . . .	5,000	60	60,000,000	60,000,000	14.28-33.66	32.78-46.80	0.41-1.5
7. S.W. of Chitalgur (18°51' : 80°05') area . . .	6,000	30	36,000,000	36,000,000	—	—	—

cement grade limestone (a lower band of about 18.3m. thickness and an upper middle band of about 24.5m. thickness). The inferred reserves are 1.5 million tonnes. The occurrence was recorded earlier by Dutt.

Betul district

A greyish white fine-grained limestone, with a strike W.N.W.—E.S.E. and dipping towards N.N.E. at an angle of 35° , occurs about 2.5 km. east of Topidhana ($21^\circ 29' : 78^\circ 57'$). A sample of this limestone showed 49.76% of CaO.

In 1939, D.S. Bhattacharji reported (West, 1949) that calcareous tufa locally burnt for lime, is found at 1.2 km. E. by N. of Bijaseni ($21^\circ 41' : 77^\circ 54'$) and also at 800 m. S.W. of Bachai ($22^\circ 07' : 77^\circ 53'$). He also reported in the following year (Krishnan, 1953) minor occurrences of travertine from Pachama ($22^\circ 00' : 78^\circ 06'$), Ronjhra ($22^\circ 02' : 78^\circ 10'$), Bhopali ($22^\circ 02' : 78^\circ 05'$), Bashardi ($22^\circ 04' : 77^\circ 56'$) and Keolajhar ($22^\circ 07' : 77^\circ 53'$).

Bhopal district

J. Narayanamurthy (Krishnan, 1953b) investigated the limestone deposits, which occur in an area lying between latitudes $22^\circ 48'$ and $22^\circ 52'$ and longitudes $77^\circ 34'$ and $77^\circ 38'$. One of these is situated north of Yarnagar and extends from Ginnur Fort to 3.2 km. west of the main railway line; the second stretches from Khanpur ($22^\circ 48' : 77^\circ 51'$) in the west to Midghat railway station in the east. The principal outcrops occur in the following areas: north of Ginnurgarh hill ($22^\circ 58' : 77^\circ 32'$), N.W. of Ginnurgarh hill, Gagra ($22^\circ 52' : 77^\circ 34'$), Chamilikho ($22^\circ 52' : 77^\circ 34'$), Ahirgarh ($22^\circ 52' : 77^\circ 34'$) and Bhinkothi ($22^\circ 51' : 77^\circ 36'$).

In the Ginnurgarh hill the two limestone horizons are well exposed with intervening thin bands of Ginnurgarh shales. The upper horizon, which is about 13.5—15m. thick, caps the hill. It is thin bedded and shows variations in texture and colour. Some of the beds are cream coloured, hard and tough, while the others are greenish, soft and flaggy. The lower horizon bears numerous shale partings and is predominantly red in colour.

The total reserves have been estimated at 28 million tonnes. The majority of the 40 samples has a high percentage of insolubles, ranging from 30 to 40%. Only six of the samples analysed have more than 40% lime. The lime content in the rest is below 35.1% and MgO is less than 2%.

Bilaspur district

B. N. Sinha (Krishnan, 1954c) reported extensive deposits of limestone near Gobripat ($22^\circ 17' : 81^\circ 59'$), south of Lormi near Maharpur ($22^\circ 15' : 81^\circ 43'$), Bankat Nawagaon ($22^\circ 16' : 81^\circ 43'$), on the hill Δ 1930 (ft.) at three kilometres to the north of Paraswara ($22^\circ 19' : 81^\circ 44'$), around Baradwar ($22^\circ 15' : 81^\circ 58'$), between Amne ($22^\circ 13' : 81^\circ 54'$) and Mahuakapa ($22^\circ 14' : 81^\circ 54'$), west of Pohgaria ($22^\circ 14' : 81^\circ 54'$), around Belpan ($22^\circ 13' : 81^\circ 53'$), about a kilometre to the east of Limha ($22^\circ 14' : 81^\circ 50'$), and around Bijaipur ($22^\circ 14' : 81^\circ 48'$). The chemical analyses of six samples collected from the area reveal that the material is not of good quality, CaO varying from 27.30 to 30.51% and MgO from 19.76 to 20.45%.

Sinha (Krishnan, 1958) reported the occurrence of siliceous and impure limestones of no economic importance near Badaura (22°18' : 81°26'), Jhiria Kalan (22°15' : 81°28'), Narsinghpur (22°18' : 81°30'), Rahmankapa (22°16' : 81°24') and Sagona (22°17' : 81°24'). Several small deposits of tuffaceous limestone, intercalated with shales, have been noted in a *nala* about 1.5 km. east of Rahmankapa. They are too impure for use.

Sinha (Krishnan, 1958b) reported the occurrence of siliceous and impure limestone from Sagona (22°17' : 81°24'), Sildana (22°16' : 82°06') and Kota (22°18' : 82°02'). A sample from Sagona contain 4.58% of R_2O_3 , 5.41% of SiO_2 , 28.47% of CaO and 18.69% of MgO. These deposits are not of economic importance.

Sinha (Roy, 1961) reported that the Lameta limestones around Choktipani (22°44' : 81°47') and towards N.W. of Keonchi (22°38' : 81°47') on the eastern slopes of the Maikal range are burnt locally for lime.

J. Narayanamurthy (Krishnan, 1958b) recorded that in the old quarries lying to the south of Deragarh (22°00' : 18°52'), two bands of limestone each about 90 cm. thick, occurring at depths of 4m. and 9.1m. respectively from the surface, have been worked. Grey medium-grained, bedded dolomitic limestone is exposed in the *nala* section north of Chitapandaria (21°57' : 82°52'), near Akalsara (21°55' : 82°51'), Bhutidiand (21°53' : 82°52').

According to P. K. Chatterjee (West, 1950) deposits of limestone are met with in discontinuous patches beginning in the east from near Birgahami (22°01' : 82°38') and Darrabhata (22°02' : 82°37') on the western bank of the Hasdo river right up to Akaltara (22°01' : 82°25') and Latia (22°01' : 82°24') in the west. The individual limestone deposits are located at Birgahami, Darrabhata, 1.2 km. east of Pali (22°03' : 82°32'), about 1.5 km. north of Sarkhon (22°03' : 82°34'), Karmandi (22°01' : 82°36'), Karmanda (22°06' : 82°36'), around Akaltara, N.E. of Khaira (22°01' : 82°18'), north and east of Gatora (22°04' : 82°15'), S.W. of Rank (22°06' : 82°17'), Mohtara (22°00' : 82°17') and Kosamdih (22°00' : 82°18').

Limestones in these localities are fine-grained, and have no overburden, although they are sometimes interbedded with calcareous shale. The beds gently dip at 10°. The best development is near Akaltara, where the limestone belt extends straight for about 1.5 km. In several quarries near Akaltara, the limestone is nearly 7.5 m. thick. The limestones in the localities mentioned above are suitable for use in the manufacture of cement.

According to Chatterjee, the deposit at Mohtara would yield about 10.2 million tonnes of high grade material suitable for use as flux in iron and steel industry. It extends over an area of about 2.5 sq. km. According to C. N. Char, there are three limestone beds in the Mohtara area. The three beds have an average thickness of 60 cm., 53 cm. and 1.2m. respectively. A total reserve of 1.04 million tonnes of limestone of all grades have been estimated upto an average depth of 4.5 m. The quality and nature of the limestone show that out of the three beds of limestone, the first bed is of the best quality. In general, the quality of the limestone in this area has been found to be unsuitable for use as flux, as even the top bed of the limestone whose surface samples showed encouraging results gave an insoluble content as high as 10.45% after detailed prospecting. The second and third beds of limestone show a high percentage of insolubles and as such they cannot be used as flux. The limestone is low in magnesia and iron, and can be used for the manufacture of cement.

The range in chemical composition is as follows:—

	SiO ₂ %	Fe ₂ O ₃ %	Al ₂ O ₃ %	CaO %	MgO %
Bed 60 cm. thick .	4.48—9.52	0.77—1.37	1.94—5.72	37.22—48.3	0.85—4.61
Bed 53 cm. thick .	6.24—13.82	1.05—1.30	3.70—5.54	41.36—48.54	0.80—3.28
Bed 1. 2m. thick .	12.36—14.22	1.74—1.78	5.46—10.94	36.78—41.12	1.38—1.42

Chhatarpur district

P. K. Chatterjee recorded in 1942 (Krishnan, 1953) large deposits of limestone around Dharampur, Pathra, Dhimaryan (24°26' : 79°20'), Amronia and Raichor (24°29' : 79°39'). Excepting the last one, occurring in the Vindhyan, the rest are in the Bijawar series. The Amronia deposit is much silicified gradually passing into brecciated quartzite. Two beds of earthy limestone, each 2.4 to 3.0m. thick, are seen in the Ghogra *nala* gorge (one almost at the top of the gorge and other at a depth of about 30 m.).

The limestone deposits were also recorded near Kachhra (24°27' : 79°39'), Banki (24°28' : 79°38'), Pararia (24°33' : 79°47'), Mainari (24°35' : 79°48'), and Palkua (24°35' : 79°49'). These occurrences belong to the Tirohan limestone horizon of the Vindhyan system. The deposits near Palkua, Kachhra and Maindri are fairly extensive and occupy areas of 3.9 sq. km., about 2.5 sq. km. and less than 2.5 sq. km. respectively. The remaining deposits are hardly one sq. km. in area each. The quality of this limestone appears to be good.

Damoh district

K. Rajarajan (Roy, 1962c) reported a large deposit of high grade limestone (Lower Bhandar) in an area about 24 km. long and 3 to 5 km. wide. The thickness of individual limestone bands is 3 to 6m. They contain 46 to 53% CaO and low magnesia.

Dhar district

M. K. Roy Chowdhury (West, 1950) reported that crystalline limestone occurs near Bagh (22°22' : 74°50') and Jobat (22°26' : 74°37'). Nodular limestones are present south of Amjhera (22°33' : 75°09') and near Bagh.

Durg district

P. K. Chatterjee (Krishnan, 1953b) examined the limestone deposit of the following localities : Anda (21°04' : 81°17'), Arjuni (21°01' : 80°35'), Bhanpuri (21°05' : 80°56'), Chandkuri (21°07' : 81°16'), Chaweli (21°13' : 81°02'), Dhaur (21°16' : 81°22'), Dumardih (21°13' : 81°01'), Gahraghat (21°28' : 81°21'), Ghorda (21°02' : 80°57'), Gundardehi (20°57' : 81°18'), Janggri (21°14' : 81°28'), Kasaridih (21°11' : 81°18'), Khapri (21°14' : 81°18'), Khuteri (20°55' : 81°18'), Kirgi (21°04' : 80°56'), Kumhari (21°15' : 81°32'), Kuthrel (21°05' : 81°17'), Limora (20°54' : 81°17'), Meresara (21°22' : 81°22'), Morid (21°10' : 81°25'), Nandi Khundni (21°23' : 81°23'), Nawapara (21°12' :

81°16'), Patharia (21°24' : 81°22'), Phulgaon (21°10' : 81°15'), Phurena (21°11' : 81°26'), Raweldih (21°19' : 81°20'), Sahgaon (21°25' : 81°22'), Sikosa (20°52' : 81°17'), Sonth (21°11' : 81°24') and Sukhri (21°00' : 80°54').

In most of the places, there is practically no overburden and blocks of limestones crop out for nearly 30 cm. or more above the surrounding country. They are usually of a purple colour, or sometimes grey and fine-grained, traversed by calcite veins. The beds are mostly rolling, but sometimes show a dip of upto 10°.

The analytical data show that on the whole the limestone bear very-low magnesia and would prove suitable for manufacture of cement. Except for only a few cases the insolubles are high and the limestone, in general, cannot be used as flux. The range in chemical composition of the 24 samples analysed is as follows: Al_2O_3 and Fe_2O_3 %—1.40—5.81, MgO %—trace—3.04, CaO %—32.30—48.42, Loss%—27.45—39.82. Twelve samples showed SiO_2 %—7.36—12.90 and the rest showed insolubles 17.90—34.57%.

It is roughly estimated that the deposits would yield about 21,210,000 tonnes of limestone.

According to N.V.B.S. Dutt (1962), the limestones in the southern part of the Drug district occur in two separate horizons, namely (1) a lower laminated limestone of a thickness of the order of 300m., designated by him as the Charmuria limestone, and (2) as bands in a higher shale-limestone formation of a thickness of the order of 450 m., the Raipur shale-limestone. The limestone exposed at the localities Arjuni, Bhanpuri, Ghorda south of Gundardehi, Khuteri, Limora, Sikosa, Sukhri and Kirgi belong to the Charmuria horizon. The lower part of this formation is indicated as of the cement grade. The limestone bands at Chameli and Dumardih Kalan are intercalated with the top bands of the Gundardehi shale formation which succeeds the Charmuria limestone. The rest of the limestone occurrence examined by P. K. Chatterji are bands in the Raipur shale-limestone. Samples from Drug (Nawapara) and Khapri indicate the possibilities of obtaining blast-furnace grade limestone from these areas.

The Indian Bureau of Mines have estimated a reserve of 28 million tonnes of limestone in Moresara area and of 67 million tonnes in Deorjhal area. The average chemical composition of the limestone in these areas is given below :—

	SiO_2 %	R_2O_3 %	MgO %
Moresara	10.57	4.37	3.01
Deorjhal	7.31	3.03	6.78

Deorjhal area.—Block 6 is reported to contain over eight million tonnes of high grade limestone within a depth of 25m. Larger reserves of this grade is expected to be proved in the adjacent blocks. Near Nandgaon, flux grade limestone stretches for about 48 km. between Khalewa and Arjuni.

Guna district

M. K. Roy Chowdhury (West, 1950) reported the occurrence of Interrappean limestone near Guna (24°49' : 77°20').

Gwalior district

According to S. K. Srivastava (Roy, 1962d.) calcareous tufa occurs at the following places:—

Umedgarh (25°52': 77°48').—At a distance of 3.2 km. from Uredgarh downstream of the Parbati *nadi* the reserve of calcareous tufa was estimated at 55 tonnes. It analyses 79.1C% of CaCO₃.

Sakra (25°52': 77°54').—About 1,000 tonnes of calcareous tufa are available at the south of Sakra.

Sesram (25°54': 77°36').—About 400 tonnes of calcareous tufa are available here.

Ranighati (25°52': 77°56').—Calcareous tufa occurs in the form of big boulders, the reserve amounting to 26,000 tonnes. Here it contains more than 94% of CaCO₃. Calcareous tufa also occurs around Aron (25°57': 77°56').

Jabalpur district

Katni area.—G. C. Chaterji (Roy, 1961) carried out the detailed investigation of the limestone deposits in the Katni area. The dip of the beds is 20° to the west. Quarrying is possible down to a depth of 50 m. There are two definite limestone bands 7m. and 15m. thick respectively in Murwara. The lower 2.7m. section of the 15 m. band yields limestone suitable for the manufacture of calcium carbide. The chemical analyses are given below:—

	Insoluble %	R ₂ O ₃ %	CaO %	MgO %	Reserves (tonnes)
15 m. thick band . . .	..	..	..	..	..
Upper 4.5 m.	1.42	0.16	53.70	0.72	40,060
Lower 2.7 m.	1.44	0.20	54.00	0.93	50,000
7m. thick band	2.18	0.48	52.00	1.84	

A 1.5 m. thick limestone band occurs under an overburden of 15 m. near the above occurrences. The analysis of a sample is as follows:—

Insolubles %	R ₂ O ₃ %	CaO %	MgO %
1.84	0.46	52.92	1.01

Two bands of limestone, 1.5 and 10.5 m. thick respectively, occur at Bargama (23°50': 80°23'). The limestone beds dip at 20°. The limestone bands, respectively 0.6, 1.5 and 3 m. thick, occur south of the Jikaria temple (23°49': 80°23').

Jukehi—Kymore area.—According to A. B. Dutt and G. C. Chaterji (1955), the limestone quarries in this area are situated south of the Kymore range. High grade limestone suitable for the manufacture of calcium carbide is available at Amheta (24°00': 80°36') and Bistara (23°58': 80°28'). The limestone is fine-grained, compact and dense. A sample analyses as follows:

Insolubles %	R ₂ O ₃ %	CaO %	MgO %
1.02	2.22	54.10	1.16

The limestone at Kachhagawan dips N.N.W. at 45°. The top layer of the limestone is about 21m. thick and it is separated by a shaly intercalation of 1.5 m. from another limestone band below. The upper nine metres of the top limestone is interbedded with sandy beds. Below this, there is a uniform limestone horizon which on analysis gave 4.5% of insolubles.

The limestone below the shale parting is thin bedded and analyses as follows :—

Insolubles %	R ₂ O ₃ %	CaO %	MgO %
2.52	0.42	52.73	1.82

Amheta area.—According to Dutt and Chaterji (1955) the limestone crops out about 800 m. north of Amheta (24°00' : 80°35') and dips at 15° towards N.N.W. The limestone has a total thickness of about six metres, out of which the upper 2.5 m. is interlaminated with earthy matter. An average sample, after excluding the earthy matter, analysed as follows :—

Insolubles %	R ₂ O ₃ %	CaO %	MgO %
1.02	0.20	54.10	1.20

The reserves of carbide grade limestone have been estimated at 1.2 million tonnes.

Kymore area.—According to Dutt and Chaterji (1955), limestone occurs west of Koilia (24°03' : 80°40'). The limestone has been proved to a depth of 30 m. but the quality deteriorates below 13 m. The bands dip at 15° to 20° towards N.W. and is overlain by three metres of clay. The MgO content increases with depth. The insoluble content is around 2%. The limestone is suitable for the manufacture of cement.

K. Rajarajan (Roy, 1962b) recorded high grade Vindhyan limestones at Murwara and Tikaria near Katni junction (23°50' : 80°24') and also at Bistara (23°58' : 80°26'). The limestones show 47% to 51% CaO on analysis and are free from magnesias.

Jhabua district

Massive and slightly crystalline Lameta limestone occurs around Jhabua. The results of chemical analyses of this limestone are given below :—

Locality	SiO ₂ and Insolubles %	R ₂ O ₃ %	CaO %	MgO %
Satmera	7.13	2.66	—	—
Okara (22°22' : 74°45')	30.48	1.70	37.27	Trace
Makawani	5.13	1.80	—	—
Kalikhetar (22°27' : 74°36')	35.78	7.70	15.04	1.03
Jobat (22°25' : 74°37')	32.32	1.60	33.06	2.85

Mandasar district

According to M. K. Roy Chowdhury (Krishnan, 1953b), folded Nimbahera limestone occurs over a large area in the southern part of the Jawad *tahsil*. The limestone is conformable with the Suket shale above and below. It is pale bluish grey, and passes imperceptibly downward into purple shaly rock. It is being extensively quarried for building stone. The following Table gives the chemical composition of the limestone from the area.

The total thickness of the limestone has been ascertained to be more than 137 m. It is, therefore, available in very large quantities.

Analyses of the Lower Bhandar limestone

Locality	SiO ₂ or Insoluble residue %	Al ₂ O ₃ and Fe ₂ O ₃ %	CaO %	MgO %
1. Marka (24°33' : 75°33')	19.42	3.48	41.61	1.11
2. Subakhora : (24°32' : 74°52')	18.59	4.11	41.82	1.18
3. Khera : (24°34' : 74°49')	23.89	4.10	36.98	2.16
4. Khar : (24°36' : 74°49')	12.82	3.50	37.48	8.12
5. Ditto	23.88	2.12	40.74	Trace
6. Damodarpura (24°33' : 74°48')	10.42	5.02	47.19	„
7. Ditto	30.72	2.34	36.98	„
8. Kundka (24°32' : 74°48')	16.64	2.61	43.40	1.23
9. Naygaon (24°33' : 74°47')	15.94	3.61	36.10	7.50
10. Kesharpura (24°33' : 74°46')	11.33	3.71	46.64	Trace
11. Bisalwas (24°31' : 74°48')	15.85	3.80	44.51	0.87
12. Ditto	25.43	2.02	40.46	2.02

Morena district

M. K. Roy Chowdhury (Krishnan, 1953b) investigated the Lower Bhandar limestone band, running in a north-south direction across the district, the best exposures are on the lower slopes of the ridges between Kailaras (26°19' : 77°39') and Palpur (25°49' : 77°11'). The total thickness of the limestone stage here exceeds 137 m. The limestone is usually siliceous and dolomitic, but good quality grey or chocolate coloured limestone occurs between Kailaras and Bakarpura (26°15' : 77°31') and also between Jawahirgarh (26°09' : 77°20') and Garhi (26°07' : 77°21'). The former area is under lease to the Associated Cement Co. The workable thickness of good quality limestone in this area is more than eight metres.

The analyses of some of the limestones are given below :—

Locality	SiO ₂ or Insoluble residue %	Al ₂ O ₃ and Fe ₂ O ₃ %	MgO %	CaO %
Kailaras*	0.83	3.70	0.58	49.39
Ditto*	10.17	3.73	0.65	47.23
Ditto	26.19	4.60	Trace	38.06
Bakaspoora	7.81	3.40	„	48.60
Ditto	8.62	2.90	1.12	47.86
Semai (26°17' : 77°34')	13.92	4.21	Trace	45.40
Jowahiragarh	11.72	3.12	„	47.19
Garhi	7.04	3.40	„	49.47
Itwai (26°07' : 77°20')	9.48	3.30	1.30	46.73
Gohra (26°07' : 77°22')	7.66	3.70	Trace	48.41
Ditto	12.91	4.30	„	44.71
Upech Bara (26°07' : 77°18')	18.85	2.80	0.63	42.23
Khitarpal (26°04' : 77°19')	10.24	5.10	Trace	45.95
Iklod (26°02' : 77°20')	11.72	5.40	„	45.28
Purattari Singh (26°04' : 77°20')	12.42	4.80	„	45.63

*Analyses obtained from the report of the Imperial Inst., London.

West Nimar district

About 1.5 km. N.N.E. of Barwaha (22°15' : 76°02') dolomitic limestones are exposed over an area of 2.5 sq. km. The main exposures are located near Agarwara (22°16' : 75°59'), and between Yelam (22°16' : 75°58') and Pirakalan (22°17' : 75°58'). The individual bands vary in thickness from a few centimetres to half a metre, and contain occasional chert bands. The thickness of the limestone deposits is more than 16 m. The deposit is exposed over an area of about 250 hectares and is estimated to contain a reserve of about 220 million tonnes of limestone with an average composition of 51.5% CaCO₃, 42% MgCO₃ and 6.5% of Insolubles.

M. K. Roy Chowdhury (Krishnan, 1954C) recorded several occurrences of coralline limestone of a high grade from the western base of the Ghatia scarp, about 1.5 m. east of Nandia, west of Agarwara, 2.5 km. S.E. of Agarwara. The limestone is granular, and the thickness of the bed varies from a few metres to 4.5 m.

At the confluence of the Satbhairon *nala* with the Kamar river a deposit of calc-tufa extends for more than 200 m. in length with an average thickness of about three metres. A sample analysis gave SiO_2 -15.94%, Al_2O_3 -1.28%, Iron Oxide-2.16%, CaCO_3 -77.35%, MgCO_3 -2.74%, Alkalis-0.31% and CaSO_4 -0.22%. Another sample gave 83% of CaCO_3 . Calc-tufa is recorded at Kahianpura, Wadgoon, Shindignatia, Dhabeti, Umedra and Naklimatar. Calc-tufa is burnt for lime on a small scale.

Calcite veins in the Trap are found at Herkira, Silwad, Vegalgaon, Budipahar, Chakia, Pati, Jalkhera, Yerwade, Matarkhund and Chichiwani, and the total reserve of calcite from these veins is estimated at 25,000 tonnes.

Raipur district

Purple limestone in association with dark dolomite occurs near the tank east of the Bhatapara (21°44' : 81°57') railway station and also south of Mile post 1 on the Bhatapara-Baloda Bazar road. Similar outcrops are present S.W. of Patpur (21°43' : 81°57'). A deposit of dark grey limestone, occurring in an area of about 1.5 sq. km., has been located at 1.2 km. S.W. of Tikulia (21°43' : 81°54'). The deposit has a gentle inclination towards E.S.E. and the overburden seldom exceeds 60 cm. in thickness.

P. K. Chatterjee (West, 1950) recorded a limestone deposit between Champa (22°02' : 82°40') on the east and Bharapara (21°44' : 81°57') on the west. He investigated in 1950 (Krishnan, 1953b), the limestone deposits in the following areas: Nawagaon (21°04' : 81°53'), Salkijitia (21°03' : 81°53'), Baktara (21°05' : 81°44'), Barondha (21°05' : 82°03'), Belsondha (21°09' : 82°03'), Bhanpuri (21°17' : 81°38'), Dangania (21°14' : 81°36'), Deopuri (21°13' : 81°41'), Dumartarai (21°12' : 81°41'), Hasaud (21°13' : 81°46'), Jora (21°14' : 81°43'), Kalai (21°13' : 81°57'), Katoratalao (21°14' : 81°39'), Khushalpur (21°13' : 81°37'), Lalpur (21°12' : 81°40'), Murhena (21°09' : 82°01'), Naikbandha (21°02' : 81°45'), Nakta (21°14' : 81°47'), Nakti (21°12' : 81°44'), Nawagaon (21°02' : 81°45'), Parsathi (21°05' : 82°02'), Pensionbara (21°14' : 81°39'), Ratakat (21°12' : 82°00'), Sirikheri (21°14' : 81°44'), Singarbhatta (21°06' : 81°42'), Temri (21°12' : 81°42') and Tikrapara (21°13' : 81°39').

The analytical data reveal that the limestones contain very low magnesia and would prove suitable for the manufacture of cement. Except in a few cases, the insolubles are high and the limestone, in general, cannot be used as flux. It is roughly estimated that these deposits would yield about 17,500,000 tonnes of limestone. The range in chemical composition of the 20 samples analysed is as follows:— Al_2O_3 and Fe_2O_3 % 2.40—5.93, MgO % Trace—3.42, CaO % 32.09—48.03, Loss% 27.28—41.10. Six samples showed SiO_2 % 5.28—16.10, and the rest showed Insolubles% 18.02—34.27.

According to Rajarajan (1957) the limestone sample collected from Dangaulia near Raipur city (21°15' : 81°38') on analysis gave 49.68% of CaO and 5.75% of Fe_2O_3 . It is free from magnesia.

According to N.V.B.S. Dutt (1962) the limestones of the southern part of Raipur district belong to two distinct geological horizons, namely (1) the Charmuria grey laminated limestone, and (2) as cryptocrystalline bands in the Raipur shale-limestone, separated by of the Gundardehi shale and the Khairagarh sandstone, as in the Durg district. The limestones from Charmuria (20°52' : 81°43'), Dhaurabhata (20°51' : 81°49'), Mauri

Goji (20°55' : 81°48'), Nawapara (20°58' : 81°51'), Barbhata (20°59' : 82°00'), Silkijitia, Nawagaon, Barondha, Parsathi, Murhena, Ratakat and Kalai belong to the Charmuria formation. The lower part of it exposed at Barondha is of cement grade. The limestones from the other 19 localities investigated by P. K. Chatterjee are from the Raipur shale-limestone. The sample from Dangaria indicates a possibility of obtaining blast furnace grade limestone from that area. Cement grade limestone should be available from many of these areas.

Rewa district

According to J. Narayanamurthy (Roy, 1962d) fine-grained limestones occur over a wide area in the Rewa *tahsil*. The limestones exposed near Rewa, Sirkini Sagra, Banjuiyan and Kauwadhan (20°33' : 81°12') are mostly dolomitic and argillaceous in nature. The impure limestones occurring near Bankuiyan, Kauwadhan, Ramnai (24°33' : 81°25') and Sagara have thin cappings of ferruginous laterite up to one metre thick. The bedded grey dolomitic limestone exposed near Ramnai is used as road metal.

Near Saman (24°23' : 81°25'), a bed of grey limestone, about two metres thick, occurs below an overburden of 3.5—5m. A sample analyses 52.25% of CaO, 5.79% of SiO₂, MgO nil and 1.18% of R₂O₃. Dark grey limestone, dipping at 5° to the S.W. at Gothwa is being worked over a length of four kilometres. The CaO content of this limestone is very low and MgO is high. Cement grade limestone occurs in disconnected outcrops near Kauwadhan. A sample analyses 52.01% of CaO, 5.87% of SiO₂, MgO nil and 1.24% of R₂O₃. Limestone bands near Ramnai are also of cement grade and analyses 53.88% of CaO, 0.68% of SiO₂, MgO nil, and 4.58% of R₂O₃.

A gritty limestone bed belonging to the Lameta age extends intermittently from Umaria to Amarkantak, a distance of more than 125 km. Near Amarkantak, the Lameta rocks resemble more a calcareous grit than a limestone. However, crystalline limestone occurs to the west of Kotepatpass (23°17' : 81°09'). An average sample of the limestone analysed CaO 34.53%, MgO 3.04%, R₂O₃ 1.56% and insolubles 30.01%.

Bajnath (24°20' : 81°11') Madhopur (24°32' : 81°10') area (Bela block).—The Geological Survey of India carried out detailed investigation aided by drilling over an area of 6.3 sq. km. Three main bands—upper, middle and lower—of grey limestone, separated by shales and impure limestones are demarcated in the Bhandar limestone formation which is 80 m. thick. The chemical analyses of the samples from the different boreholes and surface trenches reveal that the Lower grey limestone which is 8 to 10 m. thick and the top six metres of upper grey limestone, contain steel melting shop and blast furnace grade limestone. A reserve of 19 million tonnes of S.M.S. grade and 23 million tonnes of B.F. grade have been estimated for the Lower grey limestone, with an overburden ratio of 1 : 2. The reserves of the upper limestone, are of the order of 9 million tonnes.

Bankuiyan (24°36' : 81°12').—The Lower grey limestone band is exposed over a wide area. Analytical data of several trench samples show that this band is about ten metres thick and is almost entirely composed of B.F. and S.M.S. grades. An inferred reserve of 40 million tonnes consisting of B.F. and S.M.S. grades is estimated in the exposed area taking three metres as the average workable thickness.

Satna district

G.V. Rao, (Krishnan, 1953b), carried out preliminary examination of the limestone deposits in Satna and Maihar areas. The limestone crops out in disconnected patches along the valley of the Tons river. In the extreme South-western outcrops, two distinct horizons of limestone, differing in colour and texture and possibly also in composition, are traceable. The material which is quarried near Maihar is massive, compact, bluish in colour and is of good quality. At times thin partings of shale alternate with limestone. Small cavities filled with calcite and narrow veins of the mineral are a common feature of these limestones.

K. Rajarajan (1961) carried out preliminary investigation of the limestone deposits in the following areas :—

Satna area.—The limestone in Satna ($24^{\circ}35'$: $80^{\circ}50'$) area is primarily high calcium non-magnesium type, though it is associated with high silica and high magnesia fractions in some places. The pure and impure bands of limestone occur as alternating layers and the beds show an inclination of 8° — 15° towards south. In the Satna area, the length of the zone with the limestone band is about 26 km. and the width 6.4 km. About 400 m. north of Majgama ($24^{\circ}35'$: $80^{\circ}49'$), the available limestone is of flux-grade. In the quarries situated about 1.6 km. W.S.W. of Sanama ($24^{\circ}39'$: $80^{\circ}52'$), the limestone beds show a dip of about 10° towards the south. Near Durjanpur (Sajjanpur) ($24^{\circ}33'$: $80^{\circ}59'$), the limestones show a dip of 15° towards the south and 10° towards S.S.W. The analyses of samples and the reserves estimated from the different localities are as follows :—

Locality.	SiO ₂ %	TiO ₂ and Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Reserves (tonnes) %
About 800 m. E.S.E. of Ahragam ($24^{\circ}36'$: $80^{\circ}49'$).	1.68	0.59	0.66	52.30	0.72	28,310,000
About 1.2 km. S.E. of Bhimkhair ($24^{\circ}39'$: $80^{\circ}46'$).	3.34	1.79	0.66	50.60	0.85	
Durjanpur (Sajjan- pur).	4.46	1.65	0.63	50.57	0.98	442,400
About 400 m. North of Majgama.	2.45	0.49	0.49	52.37	1.15	883,000
Potenda ($24^{\circ}35'$: $80^{\circ}56'$).	6.51 —14.58	1.84 —2.39	0.96 —2.23	26.46 —46.70	1.27 ¹ —15.75	3,540,000
Rewra ($24^{\circ}36'$: $80^{\circ}45'$).	1.97	0.35	0.50	53.06	1.09	221,000
Sanama . . .	2.26	0.81	0.54	53.13	1.45	883,000
Sarwana . . .	..	..	..	..	..	221,000

Nagod area.—About 1.6 km. south-west of Nagod ($24^{\circ}34'$: $80^{\circ}35'$), the exposures of limestone are seen. These are found to dip at 10° towards south west. They show greyish and brownish tints. South-west of Harduher ($24^{\circ}36'$: $80^{\circ}45'$), the limestones occur intercalated with shale. In the Nagod area, the length of the zone with limestone bands is 25 km. and the width about five kilometres. The analyses and reserves from the area are given below :—

Locality.	SiO ₂ %	TiO ₂ and Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Reserves (tonnes) %
West of Uradan ($24^{\circ}31'$: $80^{\circ}36'$).	7.25	2.18	2.02	47.94	1.19	..
800 m. E. S. E. of Patna-Khamaria ($24^{\circ}36'$: $80^{\circ}43'$).	1.59	0.80	0.73	51.76	2.39	435,60 (Khamaria)
About 2 km. E.N.E. of Khaira.	3.25	1.18	0.42	50.89	1.01	435,600
About 400 m. S.W. of Harduba ($24^{\circ}36'$: $80^{\circ}45'$).	1.90	0.60	0.68	51.59	1.38	3,484,800
Near Umri . . .	4.33	0.66	0.94	51.13	0.83	1,742,400
About 1.6 km. S. E. of Nawbasta.	8.93	1.51	1.02	47.86	1.05	435,600
Marhi . . .	..	..	..	..	..	435,600
Rairwa . . .	..	..	..	..	..	1,742,000

Total estimated reserves : 9.2 million tonnes.

Maihar area ($24^{\circ}16'$: $80^{\circ}50'$).—In the Maihar area, the length of the zone with limestone bands is 25 km. with a width of about five kilometres. At Narairah, the limestone shows a dip of 20° towards the north..

Near Pahri ($24^{\circ}16':80^{\circ}49'$), the limestone bed shows a dip of 10° towards N.N.W. The analyses of the samples from various localities and the reserves estimated are as follows:—

Locality	SiO ₂ %	TiO ₂ and Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Reserves (tonnes)
About 400 m. N.E. Tilaora.	1.87	0.42	0.55	55.65	1.56	10,454,400
S.W. of Pahri .	0.74	1.31	0.49	53.13	1.48	27,878,400
Girgita ($24^{\circ}15':80^{\circ}48'$).	0.66	0.90	0.30	54.45	0.58	
300 m. East of Emlia.	2.27	0.48	0.60	51.69	1.61	
North of Barhia ($24^{\circ}17':80^{\circ}53'$).	2.45	0.59	0.41	51.88	0.89	435,600
South of Batia .	2.28	0.55	0.45	52.94	1.03	871,200
S.E. of Sirmili .	4.28	1.23	0.75	45.36	5.45	..
Jura . . .	..	..	..	..	..	108,900
Kharondi . .	..	..	..	..	..	108,900
Narairah . .	..	..	..	..	..	217,800

Total estimated reserves : 40,075,200 or 40.5 million tonnes.

Badampur.—Grey limestones, belonging to the Rohtas stage of the Semri series, occurs in the Badampur ($24^{\circ}10':80^{\circ}49'$) area. These are grey, soft, fine-grained and thin-bedded. The limestone formation shows a prominent dip of 10° towards the north. The limestone found here is of flux-grade. Near Amgar ($24^{\circ}08':80^{\circ}48'$), the limestone beds show a dip of 20° towards the north-west. It has a flux-grade composition. In the Badampur area, the length of the limestone band is about three kilometres and the width is about 800 m. The chemical analyses of the two samples and the estimated reserves in the area are as follows:—

Locality	SiO ₂ %	TiO ₂ and Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Reserves (million tonnes)
1.6 km. west of Amgar.	2.39	0.52	0.36	52.02	1.65	..
1.6 km. S.S.W. of Badampur.	3.46	0.64	0.46	48.70	3.84	1.8

The total estimated reserves of high calcium limestone in all the four areas are about 85 million tonnes.

S. M. Mathur and H.N. Singh (Roy, 1962a) carried out detailed investigation and sampling of limestone deposits along the Satna-Allahabad railway line. The bulk of the limestone in the area is of cement grade, and occurs over an area of 78 sq. km. with a thickness of over 15 m.

Sagar district

K. Rajarajan (Krishnan, 1954c) reported white to cream coloured Inter-trappean limestone in the following localities: Dhimnoh ($24^{\circ}15' : 78^{\circ}06'$), Dhanora ($24^{\circ}13' : 78^{\circ}07'$), Bandora ($24^{\circ}14' : 78^{\circ}06'$), Semadhana ($23^{\circ}46' : 78^{\circ}37'$), Mahuakhera ($23^{\circ}47' : 78^{\circ}38'$), Mandri ($24^{\circ}16' : 78^{\circ}32'$) and Bandighatti ($24^{\circ}14' : 78^{\circ}43'$). The reserves have been estimated at 0.3 million tonnes at Semadhana and 0.7 million tonnes at Mahuakhera. A sample from Mahuakhera analysed as 89.35% of CaCO_3 , 0.29% of MgCO_3 and 8.20% of SiO_2 . A sample from Mandri analysed as 96.55% of CaCO_3 and 1.60% of MgCO_3 . The limestone is suitable for lime burning.

Rajarajan (Roy, 1962) recorded Inter-trappean limestones near Rakhanpur ($23^{\circ}50' : 78^{\circ}29'$), Hanotia Khurd ($23^{\circ}46' : 78^{\circ}21'$), Mahuakhera ($23^{\circ}42' : 78^{\circ}32'$) and Midwasa ($23^{\circ}41' : 78^{\circ}33'$). These are suitable for the manufacture of cement, but occur in small uneconomic quantities.

Rajarajan (Roy, 1962b) collected representative samples of the Bhandar limestone from Bachlon ($23^{\circ}48' : 79^{\circ}05'$), Gahakota ($23^{\circ}47' : 79^{\circ}09'$). The limestones contain 40–50% of CaO .

Shahdol district

Kedar Narain (1956) investigated a deposit of marble, about one kilometre to the north of Majhgawan ($23^{\circ}33' : 80^{\circ}47'$). The marble is associated with mica-schist and granite-gneiss. The width of the formation is about 182 m. and the outcrop is traceable over a length of more than 3.2 km. The marble can be employed as a flooring material.

Shivpuri district

J. P. Srivastava (Roy, 1962b) recorded limestone near Tunda Bhurka Khol ($25^{\circ}33' : 77^{\circ}40'$) and Jhirnia, 1.6 km. west of Manki ($30^{\circ}44' : 78^{\circ}52'$).

Sidhi district

J. Narayanamurthy and T. S. Radhakrishna (Roy, 1964) investigated the limestone in the following areas:—

Baghawar Hinauti area.—The length of the Rohtas limestone bands exposed in the Baghawar Hinauti ($24^{\circ}20' : 81^{\circ}22'$) area is about 610 m. and the average workable width of the exposure is 45 m. The reserves are estimated at about 370,000 tonnes. The chemical analyses of the samples from this area show CaO 44.57–51.03%, MgO 1.38–4.8% and SiO_2 2.4–3.80%.

Bedekalvan Dongri-Chotakalyan area.—The limestone beds dip gently towards $\text{N}20^{\circ}\text{W}$. The total length of the limestone band is 547 m. and their workable width is about 45 m. The reserves are estimated at about 718,000 tonnes. An analysis of the sample from this area indicate that the material is of flux-grade.

Tikat-Baghawa area: In the Tikat (24°28' : 81°45')—Baghawa (24°29' : 80°47') area, the limestone samples on analysis give 42.85—49.33% CaO, 0.43—4.09% MgO and 3.14—7.61% SiO₂.

Barora—Chuli area: The limestones of Barora Chuli (24°23' : 81°44') area are mostly flaggy in nature, dipping at 35° to 40° to N. 20°W. The reserves in the area are estimated at about 219,000 tonnes.

The total reserves of limestone available in the areas examined are about 2,296,000 tonnes.

F. Ahmad (Krishnan, 1954b) recorded a number of beds of marble in the Singrauli coalfield area. He reported that the marble occurring east of Koelkut (23°37' : 82°32') is pure white, and that to the S. W. of Manjoli (24°50' : 82°37') it contains limonite specks. Marble also occurs to the west of Bahari (23°55' : 82°33'). The beds S. W. of Manadha (23°58' : 82°38') are perhaps the best for exploration. The colour, however, varies in different beds, but this quality may be utilised to produce different coloured slabs from the same locality. Ahmad considered some of the marbles as being suitable for building material.

Kedar Narain (Roy, 1961) recorded the presence of bands of crystalline and silicious limestone from Mynkhari (24°25' : 82°04'), Khairkhont (24°19' : 82°04') Chandrai (24°19' : 82°08') and Ponri (24°19' : 82°06'). Some of these can be suitably employed for constructional purposes.

REFERENCES

- AUDEN, J. B., 1950.—Cement, *Bull. Geol. Surv. Ind.* Ser. A, No. 4.
- BOROAII, S. K., 1956.—Minerals in Madhya Pradesh. Government of Madhya Pradesh.
- CHAR, C. N.,—Report on the limestone prospecting near Mahatara, Bilaspur district. Department of Geology and Mining, M. P.
- DUTT, A. B. and Chatterji, G. C., 1955.—High grade limestone in the Central Provinces (Madhya Pradesh) for calcium carbide manufacture. *Rec. Geol. Surv. Ind.*, Vol. 84, pt. 3, pp. 367-394.
- DUTT, N. V. B. S., 1962.—Chemical composition of certain limestone formations of Madhya Pradesh and Andhra Pradesh. *Indian Minerals*, Vol. 16, No. 4, pp. 367-379.
- , 1963.—Stratigraphy and Correlation of the Indravati series (Purana group) of Bastar district. (M. P.). *Journ. Geol. Soc. India*, Vol. 4, pp. 35-48.
- , 1964.—Industrialisation of Dandakaranya. *South Eastern Railway Magazine*, Vol. 7, No. 12.
- KEDAR NARAIN, 1956.—A report on mineral investigation in Shahdol district.
- KRISHNAN, M. S., 1963.—General Report for 1940, 41 and 42. *Rec. Geol. Surv. Ind.* Vol. 79, pt. 1, p. 70.
- , 1953b.—General report for 1950, *Rec. Geol. Surv. Ind.*, Vol. 84, pt. 1, pp. 83, 87 & 98.
- , 1954.—General report for 1943, 44, 45 and 46. *Rec. Geol. Surv. Ind.*, Vol. 79, Pt. 2, p. 433.
- , 1954b.—General Report for the year 1951. *Rec. Geol. Surv. Ind.*, Vol. 85, pt. 1.
- , 1954c.—General Report for the year 1952. *Rec. Geol. Surv. Ind.*, Vol. 86, pt. 1, p. 108.

REFERENCES—concl'd.

- KRISHNAN, M. S., 1958.—General Report for the year 1953. *Rec. Geol. Surv. Ind.*, Vol. 87, pt. 1.
- , 1958b.—General Report for the year 1954. *Rec. Geol. Surv. Ind.*, Vol. 88, pt. 1, p. 121.
- , Mineral Resources of C. P. and Berar. *Rec. Geol. Surv. Ind.*, Vol. 74, pt. 3, pp. 395-97.
- MATHUR, S. M.—Geological Survey and mineral resources of portions of Raigarh State (Chattisgarh).
- MATHUR, S. M. and Singh, H. N.—Note on the Traverses through Bijawar rock Chhatarpur district, M. P.
- NARAYANAMURTHY, J.—Systematic mapping in parts of Sukkti and Raigarh Tehsil of Bilaspur and Raigarh districts, M. P.
- NARAYANAMURTHY, J. and RADHAKRISHNA, T. S.—1961.—A report on the investigation of limestone deposits in Sidhi district, M. P.
- RAJABAJAN, K., 1961.—Report on the investigation of limestone deposits in Satna district, M. P.
- ROY CHOWDHURY, M. K., 1955.—Economic geology and mineral resources of Madhya Bharat. *Bull. Geol. Surv. Ind.*, Eco. Geol. Ser. A, No. 10.
- ROY, B. C., 1961.—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, pt. 1, pp. 119 & 121.
- , 1962.—General Report for 1956. *Rec. Geol. Surv. Ind.*, Vol. 91, Pt. 1.
- , 1962b.—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. 1, pp. 44-45.
- , 1962 C.—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, Pt. 1, pp. 43-45.
- , 1962 d.—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, Pt. 1, p. 74.
- , 1964.—General Report for 1961. *Rec. Geol. Surv. Ind.*, Vol. 95, Pt. 1 (in the press).
- SHARMA V. P. and ATRAM, N. S., 1961-62.—Report on the detailed mapping and sampling of Kanger limestone in sheet 65 F/13 and J/1 and 65 E/16, Jagdalpur Tehsil, Bastar district, M. P.
- SHUKLA, K. D. and SUBRAMANYAM, M. R., 1958.—Geology of the Sonawani area north of Ram Rama, Balaghat district, M. P.
- SINOR, K. P.,—Limestones, Iron-ores, ochres, Fire-clay deposits, etc. *Bull. No. 4, Geol. Dep.*, Rewa State, pp. 1-16.
- SRIVASTAVA, S. K., 1959.—Report on the investigation of calcareous Tufa deposits in Gwalior, M. P. and collection of Bulk samples for the N.C.L., Poona.
- WEST, W. D., 1949.—General Report for 1939. *Rec. Geol. Surv. Ind.*, Vol. 78, Pt. 1, p. 38.
- , 1950.—General Report for 1949. *Rec. Geol. Surv. Ind.*, Vol. 83, Pt. 1.

LOCALITY INDEX

Balaghat district—

Latitude-Longitude

Ramrama	21°52' : 79°56'
Sirrajhari	21°55' : 79°57'
Sonawani	21°55' : 79°54'

Bastar district—

Baranji	19°09' : 81°49'
Bhopalpatnam	18°52' : 80°23'
Chitalgur	18°51' : 82°05'
Deorguda	18°58' : 81°51'
Dhurvaras	18°56' : 81°50'
Gupansar	18°52' : 81°56'
Jagdaghatti	18°51' : 81°59'
Kanger river bridge	18°55' : 81°53'
Kohlakur Dongri	18°56' : 81°52'
Kotomsar	18°53' : 81°55'
Majhar Dongri	18°54' : 81°54'
Majipal	18°53' : 81°55'
Nagalsar	18°52' : 81°59'
Potonar	19°07' : 81°53'
Sukma	18°23' : 81°40'
Timed	18°51' : 80°21'

Betul district—

Bachai	22°07' : 77°53'
Basbardi	22°04' : 77°56'
Bhopali	22°02' : 78°05'
Bijaseni	21°41' : 77°54'
Keolajhar	22°07' : 77°53'
Pachama	22°00' : 78°06'
Ronjhara	22°02' : 78°10'
Topidhana	21°29' : 78°57'

LOCALITY INDEX—*contd.**Bhopal district—*

Latitude-Longitude

Ahirgarh	22°52' : 77°34'
Bhintkothi	22°51' : 77°36'
Chamilikho	22°52' : 77°34'
Gagra	22°52' : 77°34'
Ginnurgarh hill	22°58' : 77°32'
Khanpur	22°48' : 77°51'

Bilaspur district—

Akalsara	21°55' : 82°51'
Akaltara	22°01' : 82°25'
Amne Hill Δ 1930	22°13' : 81°55'
Badaura	22°18' : 81°26'
Bankat Nawagaon	22°16' : 81°43'
Baradar	22°15' : 81°50'
Belpa	22°13' : 81°53'
Beragarh	22°00' : 81°52'
Bhutidiand	21°53' : 82°52'
Bijaipur	22°14' : 81°48'
Biraghami	22°01' : 82°38'
Birgahai	22°01' : 82°38'
Chitapandaria	21°57' : 82°52'
Darrabhata	22°02' : 82°37'
Gatora	22°04' : 82°15'
Gobripat	22°17' : 81°59'
Jhiriakalan	22°15' : 81°28'
Karmandi	22°06' : 82°36'
Karmandi	22°01' : 82°36'
Keonchi	22°38' : 81°47'
Khaira	22°01' : 82°18'
Kosamdih	22°00' : 82°18'
Latia	22°01' : 82°24'
Limha	22°14' : 81°50'

LOCALITY INDEX —*contd.**Bilaspur district—contd.*

Latitude-Longitude

Maharpur	22°15' : 81°43'
Mahuakapa	22°14' : 81°54'
Mohtara	22°00' : 82°17'
Narsinghpur	22°18' : 81°30'
Pali	22°03' : 82°32'
Paraswara	22°19' : 81°44'
Pohgaria	22°14' : 81°54'
Rahmankppa	22°16' : 81°24'
Rank	22°06' : 82°17'
Sagona	22°17' : 81°24'
Sarkhon	22°03' : 82°34'
Sildana	22°16' : 82°06'

Chhatarpur district—

Banki	24°28' : 79°38'
Dhimarwan	24°26' : 79°20'
Katchra	24°27' : 79°39'
Mainari	24°35' : 79°48'
Palkua	24°35' : 79°49'
Pararia	24°33' : 79°47'
Raichor	24°29' : 79°39'

Dhar district—

Amjhera	22°33' : 75°09'
Bagh	22°22' : 74°50'
Jobat	22°26' : 74°37'

Durg district—

Anda	21°04' : 81°17'
Arjuni	21°01' : 80°53'
Bhanpuri	21°05' : 80°56'
Chandkhuri	21°07' : 81°16'
Chaweli	21°13' : 81°02'

LOCALITY INDEX—*contd.**Durg district—contd.*

Latitude-Longitude

Darba	21°50' : 81°48'
Dhaur	21°16' : 81°22'
Dumardih	21°13' : 81°01'
Gahraghat	21°28' : 81°21'
Gundardehi	20°57' : 81°18'
Janggri	21°14' : 81°28'
Kasaridih	21°11' : 81°18'
Khapri	21°14' : 81°18'
Khuteri	20°55' : 81°18'
Kirgi	21°04' : 80°56'
Kumhari	21°15' : 81°32'
Kuthrel	21°05' : 81°17'
Limora	21°54' : 81°17'
Merenara	21°22' : 81°22'
Marid	21°10' : 81°25'
Nandi Khundni	21°23' : 81°23'
Nawapara	21°12' : 81°16'
Patharia	21°24' : 81°22'
Phulgaon	21°10' : 81°15'
Phursua	21°11' : 81°26'
Raweldih	21°19' : 81°20'
Sahgaon	21°25' : 81°22'
Sikosa	20°52' : 81°17'
Somini	21°11' : 81°27'
Sonth	21°11' : 81°24'
Sukhri	21°10' : 80°54'

Guna district—

Guna	24°49' : 77°20'
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Gwalior district—

Aron	25°37' : 77°56'
Ranighati	25°52' : 77°56'

LOCALITY INDEX—*contd.*

<i>Gwalior district—contd.</i>	Latitude	Longitude
Sekra	25°52' : 77°54'	
Sesram	25°54' : 77°36'	
Umedgarh	25°52' : 77°48'	
<i>Jabalpur district—</i>		
Amheta	24°00' : 80°36'	
Bargama	23°50' : 80°23'	
Bistara	23°58' : 80°28'	
Jikaria temple	23°49' : 80°23'	
Katni junction	23°50' : 80°24'	
<i>Jhabua district—</i>		
Jobat	22°25' : 74°37'	
Kalikhetar	22°27' : 74°36'	
Okara	22°22' : 74°45'	
<i>Mandasar district—</i>		
Bisalwas	24°31' : 74°48'	
Damodarpura	24°33' : 74°48'	
Kesharpura	24°33' : 74°46'	
Khar	24°36' : 74°49'	
Khera	24°34' : 74°49'	
Kundka	24°32' : 74°48'	
Marka	24°33' : 74°33'	
Naygaon	24°33' : 74°47'	
Subakhera	24°32' : 74°52'	
<i>Morena district—</i>		
Bakarpooora	26°15' : 77°31'	
Garhi	26°07' : 77°21'	
Gohra	26°07' : 77°20'	
Iklod	26°02' : 77°20'	
Itwai	26°07' : 77°20'	

LOCALITY INDEX—*contd.**Morena district—contd.*

Latitude-Longitude

Jowahargarh	26°09' : 77°20'
Kailavas	26°19' : 77°39'
Khitarpal	26°04' : 77°19'
Palpur	25°49' : 77°11'
Purattari Singh	26°04' : 77°20'
Semai	26°17' : 77°34'
Upech Bara	26°07' : 77°18'

West Nimar district—

Agarwara	22°15' : 75°55'
Barwaha	22°15' : 76°02'
Kalianpura	22°00' : 74°50'
Pirakalan	22°17' : 75°58'
Yelam	22°16' : 75°58'

Raipur district—

Abhanpur	21°04' : 81°45'
Baktara	21°05' : 81°44'
Barbhata	20°59' : 82°00'
Barondha	21°05' : 82°03'
Belsondha	21°09' : 82°03'
Bendri	21°08' : 81°43'
Bhampur	21°17' : 81°38'
Bharapara	21°44' : 81°57'
Biroda	21°05' : 81°42'
Champa	22°02' : 82°40'
Charmuria	20°52' : 81°43'
Charoda	21°23' : 81°40'
Dangania	21°14' : 81°36'
Darba	21°16' : 81°48'
Dhaurabhata	20°51' : 81°49'

LOCALITY INDEX—*contd.**Raipur district—contd.*

Latitude-Longitude

Dumartarai	21°12' : 81°41'
Ghorda	21°02' : 81°57'
Hasaud	21°13' : 81°46'
Jora	21°14' : 81°43'
Kalai	21°13' : 81°57'
Katoratalao	21°14' : 81°39'
Khushalpur	21°13' : 81°37'
Lalpur	21°12' : 81°40'
Mauri (Goji)	20°55' : 81°48'
Murhana	21°09' : 82°01'
Naikbandha	21°02' : 81°45'
Nakta	21°14' : 81°47'
Nakti	21°12' : 81°44'
Nawagaon	21°02' : 81°45'
Paopuri	21°13' : 81°41'
Parsathi	21°05' : 82°02'
Pensionbara	21°14' : 81°39'
Rajan Nawapara	20°58' : 81°52'
Ratakat	21°12' : 82°00'
Raipur city	21°15' : 81°38'
Salkijitia	21°03' : 81°53'
Sankra	21°34' : 81°42'
Serikhari	21°14' : 81°44'
Siltara	21°21' : 81°39'
Sirikhodi	21°14' : 81°44'
Tamri	21°12' : 81°42'
Taria	21°25' : 81°41'
Tikrapara	21°13' : 81°39'
Tikulin	21°45' : 81°54'

LOCALITY INDEX—*contd.*

<i>Rewa district—</i>	Latitude	Longitude
Kauwadhan	20°33' : 81°12'	
Kotepat pass	23°17' : 81°09'	
Majgawan	24°35' : 81°26'	
Ramnai	24°33' : 81°25'	
Rewa	24°30' : 81°15'	
Saman	24°23' : 81°25'	
<i>Satna district—</i>		
Ahrgam	24°36' : 80°49'	
Amgar	24°08' : 80°48'	
Badanpur	24°10' : 80°49'	
Barhia	24°17' : 80°53'	
Batia	24°15' : 80°50'	
Bhimkhair	24°39' : 80°46'	
Durjanpur	24°33' : 80°59'	
Givgita	24°15' : 80°48'	
Harduher	24°38' : 80°45'	
Khaira	24°35' : 80°35'	
Majguma	24°35' : 80°49'	
Nagod	24°34' : 80°35'	
Pahri	24°16' : 80°49'	
Khamaria	24°36' : 80°43'	
Potenda	24°38' : 80°56'	
Rewra	24°36' : 80°45'	
Sanama	24°39' : 80°52'	
Satna	24°35' : 80°50'	
Tileora	24°16' : 80°50'	
Umri	24°23' : 80°30'	
Uradan	24°31' : 80°36'	

LOCALITY INDEX—*contd.*

<i>Sagar district—</i>	Latitude-Longitude
Bachlon	23°48' : 79°05'
Bandighatti	24°14' : 78°43'
Bandora	24°14' : 78°08'
Dhanora	24°13' : 78°07'
Dhimnoli	24°15' : 78°06'
Gahakota	23°47' : 79°09'
Hanotia Khurd	23°46' : 78°21'
Mahuakhara	23°42' : 78°31'
Mahurakhara	23°47' : 78°36'
Mandri	24°16' : 78°32'
Midwisa	23°41' : 78°33'
Rakhanpur	23°50' : 78°26'
Semadhana	23°46' : 78°37'

Shahdol district—

Majhgawan	23°33' : 80°47'
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Shivpuri district—

Manki	25°44' : 78°52'
Tunda-Bhurka Khoh	25°33' : 77°40'

Sidhi district—

Baghawa	24°29' : 80°47'
Baghwar Hinauti	24°20' : 81°22'
Bahari	23°53' : 82°33'
Barora	24°20' : 81°46'
Chandrai	24°19' : 82°08'
Chuli	24°23' : 81°44'
Khairkhout	24°19' : 82°04'
Koelkut	23°57' : 82°32'
Manadhe	23°58' : 82°38'

LOCALITY INDEX—*concl.**Sidhi district—contd.*

Latitude-Longitude

Marjoli	24°50' : 82°37'
Myakhari	24°25' : 82°04'
Ponti	24°19' : 82°06'
Tikat	24°28' : 81°45'

MADRAS

Chingelput district

According to R.N.P. Arogyaswamy (1957), shell deposits occur in thin bands along the fringes of the backwaters (rarely exceeding 3 cm. in thickness) and are not of any economic importance. The total quantity of shell is of the order of 1,000 tonnes.

Coimbatore district

In the hills near Madukkarai ($10^{\circ}54' : 76^{\circ}57'$), extensive bands of crystalline limestone occur interbedded with gneissic rocks. The total length of the limestone band is 11 km. and the width varies from 50 to 130 m.

Madurai district

Puvandi ($9^{\circ}51' : 78^{\circ}18'$)—A band of crystalline limestone occurs a little to the north of the 13th mile-stone on the Madura-Sivaganga Road. It strikes E.N.E.—W.S.W., and is traced for a length of 90 m. with an average width of 9 m. The material is of good quality.

Sunnambur ($9^{\circ}52' : 18^{\circ}17'$)—A limestone band 600 m. long and 90 to 210 m. wide is noted near the village. Another small exposure is noted 200 m. south of this band. These bands are mostly of high grade with some impure material towards its western end.

The reserves of Puvandi-Sunnambur bands were estimated at 1.01 million tonnes (Krishnan 1951).

Tirumal ($9^{\circ}43' : 78^{\circ}38'$)—A double band of crystalline limestone has been traced over a distance of 3.1 kilometres. Some good grade material is noted along with calciphyre. Two more small bands are noted in the vicinity.

Two small bands occur west of Kokkulam, about 1.6 kilometres north of Tirumal outcrop. Part of this band contains good quality stone.

North of Sadumbakulam, on the left bank of the Gondar, a few kilometres east of Kokkulam there is another occurrence of crystalline limestone.

South Arcot-Pondicherry Area

According to C. Ramaswamy and C. K. R. Sastry (1956), the Cretaceous limestone belt of this region can be sub-divided into the following areas:—

Tuttipattu ($11^{\circ}58' : 79^{\circ}43'$)-*Mettuveli* ($11^{\circ}58' : 79^{\circ}43'$) area.—Limestone occurs as a thin bed ranging in thickness from 2 to 12 cm. Veins and stringers of calcite are present in the limestone bed. The CaO content varies from 27.17 to 40.57% with traces of MgO. After beneficiation, the limestone can be used for cement manufacture. Assuming that the limestone occupies an area of 1600 m. by 800 m., the reserves of limestone have been estimated at 698,000 tonnes.

Karasur (11°59' : 79°44') Kadapperikuppam (11°59' : 79°44') area :— Fine-grained, buff-coloured limestone varying in thickness from 3 to 15 cm. occur below an overburden of 1—2.5 m. of clay. The reserves of cement grade limestone have been estimated at 850,000 tonnes. Three-fourths of the total reserves are in the Pondicherry area and one-fourth in the South Arcot district.

Sedarapattu (11°59' : 79°45')-Akasampattu (12°01' : 79°46') area .—Grey coloured and highly fossiliferous limestone covers an area of 0.5 sq. km. with an average thickness of 50 cm. The CaO content of the limestone varies from 26.32 to 51.04%. This area is estimated to contain 2.4 million tonnes of limestone (two-thirds of the total reserves are in Pondicherry area and the rest in the South Arcot district).

Turuvai (12°01' : 79°47')-Rayapuduppakkam area.—Around Pulichehapallam (12°02' : 79°45') and Rayapuduppakkam (12°02' : 79°48') fine-grained, cement grade limestone amounting to 442,500 tonnes, occurs below 1 to 1.5 m. of clay.

Pulichehapallam (12°02' : 79°45') area.—Arenaceous limestone occurring nearly five metres below the ground level becomes conglomeratic at depth.

A total of about 3.8 million tonnes of cement grade limestone are available in Pondicherry.

Of 26 analyses, 10 had more than 40% CaO with traces of MgO. The variation in chemical composition of the 10 analyses is as follows :—

SiO ₂ + Insolubles	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
3.79—21.86%	1.68—1.87%	1.27—1.68%	40.57—51.04%	Trace

Ramnad district

According to S. Narayanaswamy and V. Gopal (1949), the crystalline limestone band near Pandalkudi (9°24' : 78°07') is 68 to 83 m. wide and extends in a N.W.—S.E. direction (dips 60°—70° to the north-east) for a length of 6.5 km. The limestone is mainly medium to coarse-grained, and is of white calcitic variety. About a dozen other minor bands of limestone occur around Pandalkudi. The majority of these are narrow intercalations varying in width from 3 to 20 m. and are of no great length. The limestones in these are mostly impure and show much calc-magnesium silicates.

Out of 11 analyses made, 10 had less than 5% Insolubles. The variation in chemical composition of the 10 analyses is given below :—

Insolubles and SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
0.78—3.26%	0.24—1.21%	0.29—1.20%	51.87—54.02%	Trace—0.92%

The reserves of cement grade limestone are of the order of 1.5 million tonnes and those of flux-grade are of the order of 725,000 tonnes down to a depth of six metres.

Palyanattam (9°33' : 78°01') area.—According to S. Narayanaswamy and V. Gopal (1949), the limestone band extends under a cover of 1 to 2 m. of black soil for nearly 6.4 km. The dips are 40°—60° towards N.N.E. The band ranges in width from 30 to 120 m.

From the analyses of eight representative samples, six show insoluble less than 5%. The range in composition of these six samples is given below :—

Insolubles and SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
1.06—4.80%	0.26—1.46%	0.29—1.54%	50.40—54.68%	Trace — 1.55%

The reserves of 840,000 tonnes of flux-grade and 0.6 million tonnes of cement grade limestone, down to a depth of six metres, have been estimated.

Chinnayyapuram band.—According to S. Narayanaswamy and V. Gopal (1949), the limestone occurs as a band 80—85 m. in width and extends in N.W.—S.E. direction for about 1.5 km. The band carries fairly good quality, medium to coarse-grained, white calcitic limestone with some patches containing magnesium silicates. The analysis of a sample is given below :—

Insolubles and SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %
5.40	0.85	1.64	50.90	Trace

The reserves of flux-grade limestone down to a depth of six metres are 460,000 tonnes.

The reserves of cement grade limestone down to a depth of six metres are 920,000 tonnes.

Economic possibilities.—These limestones are suitable for the manufacture of Portland cement. The CaCO₃ ranges from 84.2% to 97.6%, MgO and Fe₂O₃ are less than 2%, and the insolubles and SiO₂ are within 11%. The reserves of at least 360,000 tonnes at Paṇḍalkudi ; 420,000 tonnes at Palavanattam, 230,000 tonnes at Chinnayyapuram are suitable for bleaching powder and a minimum of about 250,000 tonnes are suitable for manufacture of calcium carbide. The reserves of flux-grade limestone are 600,000 tonnes.

Coral limestones occur along the Ramnad coast near Upper Tannitivu, Shulitivu, Nallatannitivu, Anaiparaitivu, Balayamnaitivu, Appa tivu and Talairi tivu, etc. The reserves of all these localities were estimated at 6.1 million tonnes.

Salem district

M. S. Krishnan (1942) and N. K. N. Aiyengar (1945) investigated the crystalline limestones in the Tiruchengodu and Namakkal taluks of this district. A short summary of the results is given below :—

Ardhanaripalaiyam (11°11' : 78°00')—Limestone is exposed E.S.E. of the village for a length of 80 m. with a width of 50 cm. The analysis of one sample of this limestone is given below :—

SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %
0.20	0.37	0.05	53.01	2.51

About 400 tonnes of flux-grade limestone have been estimated upto a depth of 30 m.

Nayakkannpalaiyam ($11^{\circ}15' : 78^{\circ}00'$) : A limestone band, one metre wide, runs through the village in a NW-SE direction for a length of 80 m. Two other parallel bands of similar thickness occur north-east of the village. The reserves of limestone are, 1,200 tonnes, down to a depth of 30 m.

Kuttikkaranpalaiyam ($11^{\circ}15' : 78^{\circ}01'$).—Two small limestone bands, each 60 cm thick, occur south-east of the village. The analysis of a sample of this limestone is as follows :—

SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %
0.70	0.32	0.39	52.12	2.86

Pirandagam ($11^{\circ}15' : 78^{\circ}02'$).—The small limestone bands 1.5 m. and 2.5 m. thick respectively occur W.N.W. of the village. The results of chemical analyses of a sample of limestone are given below :—

SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %
0.01	0.11	0.09	52.87	2.49

A band of cement grade limestone occurring over a length of 180 m. with a width of 25 m. near Nadandai ($11^{\circ}12' : 77^{\circ}59'$), has been estimated to contain 200 tonnes down to a depth of 30 m.

Dasinayakanpalaiyam ($11^{\circ}27' : 77^{\circ}55'$).—Three small bands of limestone, each about 15 m. long and three metres thick, occur south of the village.

Vakkalippatti ($11^{\circ}25' : 77^{\circ}55'$).—White granular limestone occurs over an area of 400 m. $\times$ 4 m.

Kokikkalnattam ($11^{\circ}27' : 77^{\circ}55'$).—A limestone band 20 to 30 m. wide extends for a length of 550 m.

Some thick parallel bands of limestone occur over a length of 800 m. between Puddupalaiyam and Palappalaiyam ($11^{\circ}27' : 77^{\circ}47'$). The aggregate thickness is more than 80 m.

A thick band of limestone consisting of ten individual bands, varying in length upto 80 m. and in width upto 16 m., occur north-west of Kattappalaiyam ($11^{\circ}20' : 77^{\circ}55'$).

A limestone band, which is 800 m. long and 16 m. thick, occurs 400 m. south of Topper ($11^{\circ}06' : 78^{\circ}04'$). A few bands of crystalline limestone having a general strike of N.W.—S.E. occur at Sankaridrug ($11^{\circ}29' : 77^{\circ}52'$). The limestone bearing zone is 2.5 km. long and 400 m. wide. The dip of the limestone beds varies from 50° to 75° towards the north-east. They vary from calcitic and dolomitic rock to gneisses with little or no carbonates.

Of 65 analyses, 61 samples had less than 5% insolubles. The range in composition of the 61 samples are given below. Nine samples out of the 61 analysed have more than 5% MgO :—

Insolubles	R ₂ O ₃	CaO	MgO
0.2—4.80%	0.1—1.35%	34.72—55.7%	Trace—8.43%

In addition, limestone also occurs at the following places: Kuttampara ($11^{\circ}08' : 78^{\circ}06'$), Ramanathapuram ($11^{\circ}12' : 77^{\circ}50'$), Vadagarai Attur ($11^{\circ}08' : 77^{\circ}54'$), Mavelipalaiyam ($11^{\circ}29' : 77^{\circ}54'$), Kolenjipalaiyam ($11^{\circ}27' : 77^{\circ}51'$), Sanniyasippatti ($11^{\circ}27' : 77^{\circ}50'$), Mudalaimadayur ($11^{\circ}26' : 77^{\circ}48'$), Olaippalaiyam ($11^{\circ}06' : 78^{\circ}03'$), Pilikhilipalaiyam ($11^{\circ}09' : 78^{\circ}04'$), and Parali ($11^{\circ}07' : 78^{\circ}12'$).

The reserves of the various limestone bands of Salem down to a depth of three metres are summarised below :—

	Quantity tonnes
1. Ardhanaripalaiyam	400
2. Nayakkanpalaiyam	1,200
3. Kuttikkaranpalaiyam	100
4. Kuttamparai	1,600
5. Pirandagam	200
6. Nadandai	33,300
7. Ramanathapuram	400
8. Vadagarai Attur	1,200
9. Tiruchengodu-Namakkal road	58,000
10. Dasmayakanpalaiyam	200
11. Vakkalipatti	13,800
12. Kolikkalnattam	60,000
13. Chettippatti	73,500
14. Iveli	75,000
15. Mavelipalaiyam and south	26,000
16. Hill(1492)	10,400
17. Kolenjipalaiyam	1,100
18. Sanniyasipatti	7,000
19. Puduppalaiyam	23,100
20. Puduppalaiyam-Pulappalaiyam	175,700
21. Malappalaiyam	63,700
22. Mudalaimadayur	45,400
23. Salaipalaiyam-Kattupalaiyam	139,700
Total	741,000

South Arcot district

The Cretaceous strata contain beds of cement grade shelly limestone and massive argillaceous limestone near Sedarampattu ($11^{\circ}59' : 79^{\circ}45'$), Vanur and Sendamangalam ($11^{\circ}45' : 79^{\circ}23'$). The reserves in the Vanurottai area have been estimated at 944,000 tonnes.

Tanjore district

According to M.S. Krishnan (1951), fairly large patches of tufaceous limestone occur to the south of the Alakkudi railway station ($10^{\circ}47' : 79^{\circ}04'$) and W.S.W. of Tanjore town. The variation in chemical composition is given below :—

SiO ₂	R ₂ O ₃	CaO	MgO
2.19—6.62%	1.16—6.52%	48.43—52.72%	0.09—0.72%

Gravelly *kankar* occurs in the form of beds 30 cm. to 1 metre thick at Tirumalaisundaram ($10^{\circ}44' : 79^{\circ}01'$), Kurumpudi ($10^{\circ}42' : 79^{\circ}00'$), Marudakkudi ($10^{\circ}45' : 79^{\circ}00'$), Monnaiyankalupatte ($10^{\circ}45' : 79^{\circ}02'$), Kaliviroypettan ($10^{\circ}47' : 79^{\circ}02'$). The reserves have been estimated at about 500,000 tonnes. This *kankar* is suitable for the manufacture of lime and cement.

Tirunelveli district

According to S. Narayanaswamy (1955), the limestone deposits of the district are mainly of four types :—

- A. Crystalline limestones Most important and includes large quantities of pure calcitic rock.
- B. Tufaceous limestones and *kankar* Mostly superficial.
- C. Shell limestones Occur in coastal areas.
- D. Coral limestones Form a line of coral islands.

A. Bands of crystalline limestone occur at the following places :—

Ambasamudram taluk

Ambasamudram ($8^{\circ}42' : 77^{\circ}27'$) band.—This band consists of an impure variety of limestone varying in width from 60 to 120 m. and extends in a N.W.—S.E. direction for a length of 11.2 km. Chondradite marble occurs along with this band of limestone.

A narrow zone of coarse-grained, calcitic limestones carrying minute flakes of graphite and phlogopite occurs over an area of 90 m. by 10 m. near Uchchangulam ($8^{\circ}43' : 77^{\circ}24'$). The probable amount of cement grade limestone in this band is of the order of 25,000 tonnes down to a depth of 16 m.

Karisalpatti-Pillakulam band.—The reserves of pure quality calcite are of the order of 2,500 tonnes.

The Pudukkudi band is 18—21 m. wide and extends in a N. W.—S. E. direction for about 1.6 km. between the villages Pananjadi ($8^{\circ}44' : 77^{\circ}28'$)

and Adaichchani ($8^{\circ}45' : 77^{\circ}28'$). Two thin bands of limestone each about 15 m. and 6 m. wide occur about three kilometres E. S. E. of Killa Ambar ($8^{\circ}46' : 77^{\circ}25'$). This is an impure calciphyre, and is of no economic value.

A group of three bands of coarse-grained impure limestone, each with a width of 45 m., 60 m. and 90 m. respectively, extends for a length of 200 m. near the village Pattamdai ($8^{\circ}40' : 77^{\circ}35'$). The two northern bands are pink to white in colour. The southern band is mostly impure calc-schist.

Exposures of crystalline limestone varying in width from 15 to 22 m. occur near Mela Singamatti village ($8^{\circ}39' : 77^{\circ}26'$).

Nanguneri taluk

Limestone occurs at the following places :

A band of limestone 15 m. wide occurs in disconnected outcrops along the southern flank of the ridge east of Badmaneri ($8^{\circ}33' : 77^{\circ}34'$).

A 22 m. wide limestone band occurs near Apparkulam ($8^{\circ}34' : 77^{\circ}38'$). The reserves are estimated at 16,000 tonnes. These are used locally for lime-burning.

Sankaranaiyinarkoil taluk

Pandapuli ($9^{\circ}19' : 77^{\circ}34'$) area.—Small bands of crystalline limestone with occasional calcite bands occur over an area of 400 m. by 150 m. near Pandapuli. The strike of the bands is north-south and the dip is almost vertical. About 800 m. east of Chettiyapuam ($9^{\circ}20' : 77^{\circ}32'$), coarse white dolomitic limestone with calcite occur over an area of 180 m. $\times$ 90 m. The analysis of a sample from Chettiyapuram is as follows :—

Insolubles and SiO_2	R_2O_3	CaO	MgO
6.90 %	0.26%	42.54%	8.11%

About 2.5 km. east of Pandapuli and 800 m. south-west of Gopalapuram ($9^{\circ}19' : 77^{\circ}36'$) a band of limestone, 45 m. wide, occurs over a length of nearly 800 m. A few samples of limestone from south-west of Gopalapuram analyse as follows :—

Insolubles and SiO_2	R_2O_3	CaO	MgO
%	%	%	%
0.87	0.15	55.19	0.09
0.49	0.70	44.90	9.13
0.50	0.28	53.76	1.31
0.44	0.20	54.38	0.88

An amount of 263, 000 tonnes of flux-grade limestone is estimated from this band down to a depth of 15 m.

Utumalai zamindari.—A band of coarse white limestone occurs over an area of 360 m. by 30 m. under a three metres thick overburden of soil. The analysis of a sample of the limestone is given below :—

Insolubles and SiO ₂	R ₂ O ₃	CaO	MgO
9.42%	0.57%	46.64 %	0.18%

The reserves of cement-grade limestone have been estimated at about 38,500 tonnes down to a depth of 15 m. In view of its small extent and remoteness from lines of transport, this limestone band is used only for local lime-burning purposes.

Tinnevelly taluk

Four main bands of crystalline limestone occur at the following places :—

- (1) Near Ramayyanpatti (8°41' : 77°42')
- (2) North of Talaiyuttu (8°48' : 77°43')
- (3) Near Terku Seliyanallur (8°53' : 77°43')
- (4) North-east of Marandai (8°49' : 77°34')

(1) *Ramayyanpatti band*.—There are four main zones in this band :—

(i) Western Seturayapattur zone.—This band is 1.2 km. long and 115-130 m. wide, and dips steeply (60°-70°) to the S. S. E. The limestone is intercalated with impure materials like coccolite and calc-silicates.

(ii) Central Ramayyanpatti zone.—This is about 150 m. wide and 2.5 km. long. It strikes in an east-west direction and dip steeply southwards. This zone makes up a remarkably pure, white calcitic limestone with subordinate impure materials. The middle of the zone is covered by soil. Towards the eastern end, the zone broadens out owing to repetition by folding. The limestone is intercalated with bands of quartzite. Pockets of green and pink calcitic limestone occur at the eastern end.

(iii) Eastern Tenkulam zone.—This zone is about 80-95 m. wide and extends in an E. S. E.-W. N. W. direction. High grade coarse, calcitic material occurs only at the western end, the rest being medium grained and saccharoidal. The grade of the Ramayyanpatti limestone remains unaltered upto 8-12 m. of depth.

Of the 33 analyses, 27 had less than 5 % insolubles. The range in composition of these 27 samples is given below :—

Insolubles + SiO ₂	R ₂ O ₃	CaO	MgO	CaCO ₃	MgCO ₃
0.20—3.91 %	Trace—1.15%	47.97— 54.56 %	0.31— 6.48%	85.66— 97.68%	0.65— 13.55%

Three analyses show 5-7 % insolubles. The range in composition of these three samples is given below :—

Insolubles + SiO ₂	R ₂ O ₃	CaO	MgO
5.22—7.01 %	Trace—0.10 %	43.78—49.71%	1.63—2.72 %

Three analyses had more than 20 % insolubles. The range in composition of these three analyses is as follows:—

Insolubles + SiO ₂	R ₂ O ₃	CaO	MgO
21.59—24.71 %	0.45—1.40 %	34.97—40.70 %	0.69—7.24 %

Reserves : Ramayyanapatti area (down to 16 metres depth).

Zone	Cement grade limestone Reserves (tonnes)	Flux-grade limestone Reserves (tonnes)
Western	519,350	159,940
Central	2,076,850	766,060
Eastern	1,384,500	1,059,600

(2) *Talaiyattu band*.—This band forms the eastern continuation of the Ramayyanapatti band. The calc rocks occur as a broad zone extending for nearly 2.5 km. with an average width of 300 m. Towards the north end, the limestones gradually thin out and disappear under a debris of quartzite. The band has a strike in north-south direction and dips steeply (70°—80°) towards the west. This band is largely composed of medium-grained, saccharoidal limestone. The analysis of a sample of calcitic limestone is as follows:—

Insolubles	R ₂ O ₃	CaO	MgO
1.14%	0.22%	53.71 %	1.05 %

Bands containing calc-silicates are high in insolubles and magnesia.

In the southern 900 m. of the zone upto a depth of 15 m., including 15 cm. of overburden, 4,880,000 tonnes of cement grade limestone and 1,020,000 tonnes of flux-grade limestone are available from the entire area.

(3) *Seliyanallur band*.—A narrow band of coarse white crystalline limestone occurs near Seliyanallur. It is about 60 m. broad and extends for about 600 m. along the eastern side of the village. After an interruption for 0.2 to 1.35 km., it is again exposed for about 90 m. in a small *nala* north of Nellaittiruttu (8°52' : 77°42'). There are thin intercalations of quartzite within the band. The strike of the band is N. N. W.—S. S. E.

The material near Seliyanallur and Nellaittiruttu is of flux-grade and extends upto an assumed depth of 15 m. below the surface. The reserves are of the order of 78,000 tonnes.

B. Tufaceous limestone and *kankar* are confined chiefly to the following places:—

Kovilpatti taluk

Impure *kankar* occurs at Kayattar (8°57' : 77°47') and Turaiyur (9°06' : 77°55'). A limestone band 60—90 m. wide, extends over a length of nearly 5.5 km. in a N. W.-S. E. direction at Kalappaipatti (8°53' : 77°49') and

Kayattar ($8^{\circ}57' : 77^{\circ}47'$). The reserves are estimated at 230,000 tonnes upto a depth of 15 m. Bands of medium to coarse-grained limestone occur around Pasuvandanai ($9^{\circ}00' : 77^{\circ}58'$), Villiseri, ($9^{\circ}43' : 77^{\circ}49'$), Vagaittavu ($8^{\circ}02' : 77^{\circ}49'$), Vedakku Semmapudur ($9^{\circ}06' : 77^{\circ}58'$) and Pudur ($9^{\circ}17' : 78^{\circ}8'$), each over an area of 60 to 90 m. long and 5 to 22 m. wide.

Nanguneri taluk

The limestone band occurring near Udaiyattur ($8^{\circ}15' : 77^{\circ}44'$) and Vijayapati ($8^{\circ}11' : 77^{\circ}45'$) varies in width from 400 to 600 m. and extends for 9.5 km. Assuming a thickness of 3 to 4 m., the reserves amount to 3 million tonnes. The limestone band to the south and south-east of Kasturirangapuram ($8^{\circ}09' : 77^{\circ}46'$) is 4.8 km. long, 800 to 1,600 m. wide, and 3 to 5 m. thick. The reserves are estimated at 4 million tonnes. Limestone also occurs between Ittamoli ($8^{\circ}24' : 77^{\circ}51'$), Karitottam ($8^{\circ}23' : 77^{\circ}50'$), Tassiyavilai ($8^{\circ}20' : 77^{\circ}52'$) and Idaiyankudi ($8^{\circ}19' : 77^{\circ}53'$), the width varying from 800 to 1200 m., length from 11 to 12.8 km. and thickness from 3 to 5 m. The reserves are estimated at 6 million tonnes.

Sankaranaiyinarkoil taluk

Tufaceous limestones 400-1600 m. wide and two metres thick, occur along the streams between Nilidanallur ($9^{\circ}07' : 77^{\circ}36'$), Mahandravadi ($9^{\circ}07' : 77^{\circ}39'$), Sayamalai ($9^{\circ}05' : 77^{\circ}41'$) and Terku Konarkottai ($9^{\circ}02' : 77^{\circ}44'$) for a length of 16 km. The reserves have been estimated at ten million tonnes.

Srivaikuntam taluk

Near Karungulam ($8^{\circ}38' : 77^{\circ}51'$), the limestone deposit is in the form of a layer of gravelly *kankar*. The area measures 300—400 m. by 200 m. The layer is 1 to 2 m. thick. The reserves are estimated at 30,000 tonnes.

South of Minakshipatti ($8^{\circ}42' : 77^{\circ}58'$), the area of limestone is 400 m. by 200 m. The deposit is a gravelly *kankar*, 60 cm. to 1 m. thick. The reserves are estimated at 20,000 tonnes.

Tenkasi taluk

Tufaceous limestone and *kankar* occur at Samburvadakara ($9^{\circ}00' : 77^{\circ}23'$), Surandai ($8^{\circ}59' : 77^{\circ}26'$), Poigai ($9^{\circ}02' : 77^{\circ}23'$) and Nainaragaram ($9^{\circ}02' : 77^{\circ}20'$) over an area of 2.5 km. by 1.2 km. The reserves have been estimated at 350,000 tonnes.

Tinnevelly taluk

A limestone band, 800-1600 m. wide occurs at Itteri ($8^{\circ}38' : 77^{\circ}45'$), Alwaneri ($8^{\circ}36' : 77^{\circ}46'$), Sivandipatti ($8^{\circ}38' : 77^{\circ}47'$) and Seydunganallur ($8^{\circ}40' : 77^{\circ}50'$) for a length of 11 km. The deposit is mostly bedded tufa occurring at depths of 1 to 2 m. The reserves have been estimated at three million tonnes.

Tufaceous limestone 200 to 400 m. wide, occurs at Peltai ($8^{\circ}43' : 77^{\circ}40'$) and Rajam Pacheri ($8^{\circ}52' : 77^{\circ}47'$) for a length of 1.6 to 3 km. The reserves have been estimated at 1.2 million tonnes.

Tiruchendur taluk

Sattankulam ($8^{\circ}27' : 77^{\circ}55'$).—The limestone occurs over an area of 6.4×3.2 sq. km. The reserves are estimated at nine million tonnes.

Between Pidaneri ($8^{\circ}32' : 77^{\circ}57'$) and Eluvanamukki ($8^{\circ}31' : 77^{\circ}58'$), limestone occurs over an area of 4 km. $\times$ 1.6 km. The thickness varies from 66 cm. to 1.5 m. A large part of the material is impure and siliceous. The reserves are estimated at 500,000 tonnes.

Between Karankadal ($8^{\circ}29' : 77^{\circ}53'$), Panaikkulam ($8^{\circ}30' : 77^{\circ}52'$) and south-west of Peykulam ($8^{\circ}31' : 77^{\circ}52'$), the limestone occurs over an area of 4 km. $\times$ 800 m. with thickness upto 1.5 m. The reserves have been estimated at 180,000 tonnes.

Calcareous grits and shell limestone occur at the following localities :—

Near Kudangulam ($8^{\circ}11' : 77^{\circ}43'$) shell limestone occurs over an area of 6.5 km. by 800 m.

At Idintakari ($8^{\circ}11' : 77^{\circ}45'$), Selvamarudur ($8^{\circ}20' : 77^{\circ}02'$), Sattangulam ($8^{\circ}27' : 77^{\circ}55'$), Panamparai ($8^{\circ}28' : 77^{\circ}56'$), Nazareth ($8^{\circ}34' : 77^{\circ}59'$) the limestone deposits are impure and used as building stone.

Small deposits of loosely consolidated shelly gravel occur at Nalumavadi ($8^{\circ}35' : 78^{\circ}02'$), Nalluar ($8^{\circ}35' : 78^{\circ}04'$), Arumuganeri ($8^{\circ}34' : 78^{\circ}06'$). Coral limestones occur at the following islands off Tinnevely coast : Van Tivu, Koswari island, Keriya Shuli island and Vilangu Shuli island.

The chemical analyses of broken and consolidated corals are given below :—

	Insolubles and SiO_2	R_2O_3	CaO	MgO
	%	%	%	%
Consolidated coral .	1.08	0.52	52.27	0.18
Broken corals . .	1.36	0.34	51.92	[0.09]

These coral limestones are suitable for the manufacture of chemicals like bleaching powder, calcium carbide, etc., if the alkalies can be removed.

Tiruchirapalli district

According to M. S. Krishnan (1951), there are three major bands of crystalline limestone.

Kulittalai taluk

(a) The limestone band occurring one kilometre south of Tarakkampatti ($10^{\circ}4' : 78^{\circ}15'$) is intercalated with calc-gneiss. This band is estimated to contain 92,000 tonnes of limestone.

(b) The Allinagaram Devarmalai limestone band is about 15 km. long and 500 m. wide. It continues beyond Allinagaram ($10^{\circ}45' : 78^{\circ}18'$) eastward into Kulittalai taluk and beyond Devarmalai ($10^{\circ}44' : 78^{\circ}10'$) westward into Madura district. The reserves of this limestone band have been estimated at 400,000 tonnes.

(c) The limestone band occurring at Kuranur ($10^{\circ}47' : 78^{\circ}17'$) is five kilometres long and 350 m. wide. The reserves have been estimated at 52,000 tonnes down to a depth of three metres.

Nodules of chalky limestone occur in veins near Karai ($11^{\circ}08' : 78^{\circ}53'$), Varguppadi ($11^{\circ}09' : 78^{\circ}54'$) and Kulan ($11^{\circ}03' : 78^{\circ}51'$) in an area of three sq. km. A sample analysed as follows :—

SiO_2	Al_2O_3 & Fe_2O_3	CaO	MgO
%	%	%	%
1.12	0.05	54.6	0.62

The reserves have been estimated at 1.5 million tonnes down to a depth of four metres. These limestone nodules should be useful for lime manufacture.

Limestone occurs at Ayniapuram ($11^{\circ}07' : 78^{\circ}56'$). The reserves have been estimated at 76,000 tonnes down to a depth of three metres. A sample analyses as follows :—

$\text{SiO}_2 + \text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	CaO	MgO
%	%	%
Less than 3	51.87	1.09

Kallakkudi ($10^{\circ}58' : 78^{\circ}57'$)-Vadugarpattai ($10^{\circ}57' : 78^{\circ}56'$).—According to M. V. A. Sastry (Personal communication), two Cretaceous limestone exposures of the Uttatur stage occur near Kallakkudi and Vadugarpattai. The Kallakkudi exposure is 2 kilometres long, and varies in width from 300 metres in the northern portion to 1100 metres near Kallakkudi. The Vadugarpattai exposure is 2.7 kilometres long and 800 metres wide. The dip of the beds varies from horizontal to 4° . The cement factory of Dalmiapuram is utilising this limestone. In the Kallakkudi exposure, limestone bands as revealed by drill holes put down by the Cement factory authorities persist down to a depth of 45 metres. The CaCO_3 content of the bands in the top nine metres varies from 80 to 90 per cent. In one borehole down to a depth of 30 metre the CaCO_3 content is nearly 90 per cent. The CaCO_3 content of the entire thickness varies from 50 to 90 per cent.

REFERENCES

- AIYENGAR, N. K. N., 1945.—Crystalline limestones in Tiruchengodu and Namakkal taluks, Salem district, Madras. *G. O. No. 817*, dated 23-2-45.
- AROGYASWAMY, R. N. P., 1957.—Note on the lime shell occurrences near Govelong, Chingleput district, Madras. *G. S. I. Report* (Unpublished).
- , 1957.—Note on the lime shell occurrences near Nagapattinam, Tanjore district, Madras. *G. S. I. Report* (Unpublished).
- BALFOUR, E., 1854.—On the marbles of the Madras Presidency. *Sel. Rec. Madras Govt. Ser. I, II*, p. 5-41.
- BLANFORD, H. F., 1857.—Notes on the occurrence of crystalline limestone in Coimbatore district. *Mad. Jour. Lit. Sci.*, N. S. III, p. 60-64.
- FOOTE, R. B., 1883.—Geological structure of the Eastern Coast, etc. *Mem. Geol. Surv. Ind.*, Vol. 16, Pt. 1.

REFERENCES—*contd.*

- FOOTE, R.B., 1883.—Geology of Madura and Tirunelvely. *Mem. Geol. Surv. Ind.*, Vol 20, pp. 19, 21, 101.
- GOPAL, V., 1959.—A note on the examination of cores obtained from certain drill holes in the Pamban Channel, Ramanathapuram, Madras. *G. S. I. Report* (Unpublished).
- IYER, L. A. N., 1929.—A study of calc-gneisses, etc. of Coimbatore. *Min. Mag.* 22, pp. 121-135.
- KRISHNAN, M. S., 1942.—Crystalline limestones near Sankardirug, Salem. *Rec. Geol. Surv. Ind.*, Vol. 77, Prof. paper No. 7.
- , 1942.—Mineral deposits of the Uttatur stage of the Cretaceous of Trichonopoly. *Rec. Geol. Surv. Ind.*, Vol. 77, Prof. Paper No. 9.
- , 1951.—Mineral Resources of Madras. *Mem. Geol. Surv. Ind.*, Vol. 80.
- NARASIMHAN, A. S., 1960.—A preliminary report on the suitability of Panamporai and Eleurarmukki areas, Tirunelveli district, Madras for cement manufacture. *G.S.I. Report* (Unpublished).
- NARAYANASWAMY, S., 1942-44.—Progress Report : Limestones of Tirunelvely. *G. S. I. Report* (Unpublished).
- , 1946.—Limestones near Tirumalasamudram, Tanjore, Madras. G. O. No. 1839, dated 7-5-46.
- , 1955.—The limestone deposits of Tirunelvely district, Madras. *Rec. Geol. Surv. Ind.*, Vol. 84, Pt. 3.
- NARAYANASWAMY S. and GOPAL, V., 1949.—A note on the crystalline limestone occurrences near Pandalhadi, Palavanattam and Chinnayyepuram in the Ramnad district. *G. S. I. Report* (Unpublished.)
- RAMASWAMY, C. and SASTRY, C. K. R., 1956.—A note on the mineral reconnaissance of the Pondicherry State. *G. S. I. Report* (Unpublished).
- SUBRAMANYAM, A. P., 1946-47.—Progress Report : Limestone near Puvandi and Sunna-ambur, Madura Ramnad. *G. S. I. Report* (Unpublished).

LOCALITY INDEX

Coimbatore district—

Latitude-Longitude

Modukkarai 10°54' : 78°57'

Pondicherry area—

Akasampattu 12°01' : 79°46'

Karasur 11°58' : 79°43'

Kodapparikuppam 11°59' : 79°44'

Meltuvali 11°58' : 79°43'

Pulichchapallam 12°02' : 79°45'

Rayapuduppakam 12°02' : 79°48'

Sedarapattu 11°59' : 79°45'

Turuvai 12°01' : 79°47'

Tutlipattu 11°58' : 79°43'

Ramnad district—

Analpartivu 9°05' : 78°40'

Appativu 9°05' : 78°45'

Balayamunaitivu 9°05' : 78°40'

Balyanattam 9°33' : 78°30'

Nalla tannitivu 9°05' : 78°35'

Pandalkudi 9°23'30'' : 78°6'30''

Shulitivu 9°05' : 78°30'

Talairitivu 9°05' : 78°50'

Uppu Tannitivu 9°05' : 78°25'

Salem district—

Ardhanaripalaiyam 11°11' : 78°01'

Daippalaiyam 11°6' : 78°03'

Dasinayakanpalaiyam 11°26'30'' : 77°53'00''

LOCALITY INDEX—*contd.**Salem district—contd.*

Latitude-Longitude

Kattappalaiyam	11°19'30" : 77°55'00"
Kolenjipalaiyam	11°27' : 77°51'
Kolikkalnattam	11°26'30" : 77°55'00"
Kultikkaranpalaiyam	11°15' : 78°01'
Kuttamparai	11°08' : 78°06'
Mavalipalaiyam	11°29' : 77°54'
Mudalaimadayur	11°26' : 77°48'
Nadandai	11°12'00" : 77°58'30"
Namakkal	11°11' : 78°00'
Nayakkanpalaiyam	11°14'30" : 78°00'20"
Palappalaiyam	11°27'00" : 77°47'30"
Parali	11°07' 00" : 78°11'30"
Pirandagam	11°15' : 78°02'
Pilikkhilipalaiyam	11°08'40" : 78°04'00"
Ramanathapuram	11°11'30" : 77°58'30"
Sankaridrug	11°28'30" : 77°52'00"
Sannaiyasippatti	11°27' : 77°50'
Tiruchemgodu	11°20' : 77°50'
Toppur	11°06' : 78°04'
Vadagarai Altur	11°08' : 77°54'
Vakkalipatti	11°25' : 77°55'

South Arcot district—

Sedarampattu	11°59' : 79°45'
Sondamangalam	11°45' : 79°23'
Vanur	12°00' : 79°40'

Tanjore district—

Alakkudi	10°47' : 79°04'
Kaliviroyapettan	10°47' : 79°02'
Kurumpudi	10°42' : 79°00'

LOCALITY INDEX—*contd.**Tanjore district—contd.*

Latitude-Longitude

Monnaiyankalupatte	10°45' : 79°02' 1
Narudakkudi	10°45' : 79°00'
Tanjore	10°45' : 79°05'
Tirumalaisundaram	10°44' : 79°01'

Tirunelveli district—

Adaichchani	8°45' : 77°28'
Alwaneri	8°36' : 77°46'
Ambasamudram	8°42' : 77°27'
Apparkulam	8°34' : 77°38'
Arumuganeri	8°34' : 78°06'
Badamaneri	8°33' : 77°34'
Chettiyapuram	9°20' : 77°32'
Eluvanamukke	8°31' : 77°58'
Gopalapuram	9°19' : 77°36'
Idaiyankudi	8°19' : 77°53'
Idantakari	8°11' : 77°45'
Ittameli	8°24' : 77°51'
Itteri	8°38' : 77°45'
Kalapaipatti	8°53' : 77°41'
Karitoltam	8°23' : 77°50'
Kariya Shuli Island	8°35' : 78°15'
Karungulam	8°38' : 77°51'
Karunkadal	8°29' : 77°53'
Kasturirangapuram	8°09' : 77°46'
Kayattar	8°57' : 77°47'
Killa Amber	8°46' : 77°25'
Kosawari Island	8°50' : 78°10'
Kundangulam	8°11' : 77°43'
Mahandravadi	9°07' : 77°39'

LOCALITY INDEX—*contd.**Tirunelveli district—contd.*

Latitude-Longitude

Marandai	8°49' : 77°34'
Mela Singampatti	8°39' : 77°26'
Minakshipatti	8°42' : 77°58'
Nainarayaram	9°02' : 77°20'
Nalluar	8°35' : 78°04'
Nalumavadi	8°35' : 78°02'
Nazareth	8°34' : 77°59'
Nellaittiruttu	8°52' : 77°42'
Nilidanallur	9°07' : 77°36'
Pandapuli	9°19' : 77°34'
Pananjadi	8°44' : 77°28'
Panamparai	8°28' : 77°56'
Pansikkulam	8°30' : 77°52'
Pasuvandanai	9°00' : 77°58'
Pattemdai	8°40' : 77°35'
Peltai	8°43' : 77°40'
Peykulam	8°31' : 77°52'
Pidaneri	8°32' : 77°57'
Poigai	9°02' : 77°25'
Pudur	9°17' : 78°08'
Rajam Pacheri	8°52' : 77°47'
Ramayyanpatti	8°41' : 77°42'
Samburvadakara	9°00' : 77°23'
Sattamgulam	8°27' : 77°55'
Sayamalai	9°51' : 77°41'
Selvamarudur	8°20' : 77°02'
Seydunganallur	8°40' : 77°50'
Sivandipatti	8°38' : 77°47'
Surandai	8°59' : 77°26'
Talaiyutta	8°48' : 77°43'

LOCALITY INDEX—concl'd.

<i>Tirunelveli district—concl'd.</i>	Latitude-Longitude
Tesaiyanvilai	8°20' : 77°52' 1
Terku Konarkottai	9°02' : 77°44'
Terku Soliyanathur	8°48' : 77°43'
Turaiyur	9°06' : 77°55'
Uchchangulam	8°43' : 77°24'
Udayather	8°15' : 77°44'
Vadakku Semmapudur	9°06' : 77°58'
Vagailtavu	8°02' : 77°49'
Vantiru	8°50' : 78°10'
Vijayapati	8°11' : 77°45'
Villiveri	9°43' : 77°49'

MAHARASHTRA

Ahmednagar district

The total quantity of limestone (calcareous tufa) at Kanur (19°06' : 74°23'), Nandur (19°08' : 74°16') and Khandera Vadi (19°25' : 74°15') had been estimated at 12,200 tonnes by M. R. Sahni (Krishnan, 1955). Most of the material is of good quality and contains over 75 per cent of CaCO_3 . Inter-trappean limestone is also reported to occur in this district.

B. F. Mehta (Roy, 1962a) recorded the occurrence of calc-tufa or travertine near Pengiri (19°28' : 74°05').

Aurangabad district

D. S. Deshmukh (Roy, 1962) reports that *kankar* in the form of concretionary nodules is found along the Girija river to the north-west of Kanhori (20°07' : 75°25'). It is locally burnt for making lime.

D. S. Deshmukh (Roy, 1961) records that *kankar* in the form of concretionary nodules is abundantly found near Daulatabad (19°57' : 75°14') and 6.4 km. west of Govrai (19°47' : 75°18') in the Aurangabad district. It is collected by hand picking and burnt locally for lime.

Bombay district

Highly siliceous and cherty limestones of grey, pink and cream colour are used as building stones. They occur in abundance near Manami (16°12' : 75°11') and Yadwad (16°15' : 75°11').

Considerable quantities of *kankar* are worked for lime-burning in the neighbourhood of Harlapur (15°25' : 75°46'), Alur, Haitapur (15°17' : 75°52') and Lakkundi.

Chanda district

Limestone deposits are found in the Vindhyan and Lameta formations. They occur near Purkepar village, about 6 km. east of Nowargaoon. It is finegrained grey in colour and occurs one metre below the soil. Limestone also occurs near Kandara, Karamgotha, Nardha and Niljai.

The analyses of the samples are given below :—

Locality	Composition in percentage						
	CaCO_3	MgCO_3	SiO_2	Fe_2O_3	Al_2O_3	SO_3	Alkalies
Purkepar	86.77	2.23	9.50	0.40	0.62	Nil	0.48
Kondara (<i>nala</i> bed east of village).	86.37	1.40	10.50	0.25	0.25	CaSO_4 =0.52	0.61
Kandara (400 m. south of village in <i>nala</i> bed).	74.19	1.79	19.46	1.14	2.80	CaSO_4 =0.13	0.49
Karamgotha, (3 km. south of Warora).	77.29	1.69	17.97	0.29	2.37	Nil	0.39
Nardha (10 km. south west of Warora).	79.77	0.58	15.36	0.70	2.96	Nil	0.63
Niljai, (13 km. west of Warora).	52.55	37.01	6.19	0.40	3.54	Nil	0.31

Limestone is also found around Somanapalli (19°38'30" : 79°39') and Dongangaon (19°37' : 79°40'). But they are highly siliceous.

Kankar occurs near Warora and Bheondak in the form of surface deposits. Large amounts of *kankar* are also found in several *nala* sections in the Garchiroli *tehsil*. Analyses of *kankar* occurring near Buranj, Dengargaon, Dehigaon, Kondha, Mardha and Warora show CaCO₃ 74.6 to 82.1 per cent and SiO₂ 17.2 to 23.0 per cent.

V. R. Venkoba Rao (1960) mentioned the occurrence of large amounts of *kankar* in the several *nala* sections in the Garchinoli *tehsil*. It is locally used for lime-burning.

Nagpur district

Cherty infra-trappean limestone occurs near the Chicholi rest house, Keled and E. N. E. of Jaitgarh tank. The occurrences are not of economic importance.

Nanded district

P. V. Rao (Krishnan, 1954) reported the occurrence of dense, hard, grey and cream cherty limestones, 2.54 to 15.24 cm. thick, at various levels in the inter-trappean beds between 396 to 426 m. in topo-sheet No. 56 F/NE. It is suitable for lime making.

Ratnagiri district

Venkoba Rao (Roy, 1962) examined in detail a limestone deposit lying about 3.2 km. E. N. E. of Talera near Phonda (16°23' : 73°43'). The limestone is massive, light grey in colour, and underlies the shales and sandstones of the lower Kaladgi series. Five random samples analyses as :

No.	SiO ₂ %	R ₂ O ₃ %	CaO %	MgO %
1	11.54	3.00	44.35	2.64
2	25.30	7.50	31.25	3.33
3	10.77	4.00	44.90	2.39
4	16.66	4.00	38.06	3.26
5	7.00	2.30	48.55	1.44

The thickness of the deposit may exceed five metres. Owing to a thick overburden and poor quality, they do not seem to be of economic importance.

Y. S. Sahasrabudhe (Roy, 1962b) investigated the alleged occurrence of limestone at Kadawal (16°08' : 73°47'), Pangraed (16°08' : 78°49') and near Hanumangad (16°06' : 73°54') but came across no deposit in the area. He examined the limestone deposit associated with the lower Kaladgi shales near Kasarda (16°26' : 73°42') in the Kankavli *taluk*, where he demarcated a small zone about 518 m. in length and 30 m. in width. The limestone is suitable for the manufacture of lime.

Satara district

B. G. Deshpande (Krishnan, 1953) investigated the occurrence of limestone near Phaltam ($17^{\circ}58' : 74^{\circ}26'$). *Kankar* pebbles of no economic value are seen strown in the beds and along the *nalas*. It is only at Wakri ($17^{\circ}56' : 74^{\circ}25'$), 8 km. south-west of Phaltan, that a patch of tufa measuring about 304 m. long, 91 m. wide and 1.2 to 1.5 m. thick is seen. The material appears to be of good quality but the quantity available from the area is very small for use in the manufacture of cement. It can, however, be locally burnt for lime.

Yeotmal district

A. K. R. Hemmady (Roy, 1962 c) investigated the limestone deposits in the Wun *taluk*. He carried out a reconnaissance survey of the Vindhyan formation (topo-sheets 55 L/16 and 56 I/13), prepared large scale plans of selected quarry areas and collected samples for analyses. The probable reserves of cement grade limestone are estimated at about 101.6 million tonnes of which proved reserves are of the order of 43.69 million tonnes down to a depth of 152 m.

REFERENCES

- KRISHNAN, M. S., 1953.—General Report for 1950. *Rec. Geol. Surv. Ind.*, Vol. 84, pt. I, p. 85.
- , 1954.—General Report for 1951. *Rec. Geol. Surv. Ind.*, Vol. 85, pt. I, p. 55.
- , 1954.—General Report for 1952. *Rec. Geol. Surv. Ind.*, Vol. 86, pt. I, p. 102.
- , 1955.—General Report for 1944. *Rec. Geol. Surv. Ind.*, Vol. 79, pt. 2.
- ROY, B. C., 1951.—Mineral Resources of Bombay. Published by the Government of Bombay, pp. 87-88.
- , 1961.—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, pt. I, p. 121.
- , 1962.—General Report for 1956. *Rec. Geol. Surv., Ind.*, Vol. 91, pt. I, pp. 76, 78 and 81.
- , 1962a.—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, pt. I, p. 43.
- , 1962b.—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, pt. I, p. 43.
- , 1962c.—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, pt. I, p. 74.
- , 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.*, Vol. 95, pt. I, p. 152.
- VENKOB RAO, K. R., 1960.—A note on the investigation of a limestone deposit near Talera, Ratnagiri district. *G. S. I. Report* (Unpublished.)

LOCALITY INDEX

Ahmednagar district—

Latitude-Longitude

Kanur	19°06' : 74°23'
Nandur	19°08' : 74°16'
Khandera Vadi	19°25' : 74°15'
Pemgiri	19°28' : 74°05'

Aurangabad district—

Daulatabad	19°57' : 75°14'
Govrai	19°47' : 75°18'
Kanhori	20°07'30" : 75°25'30"

Bombay district—

Mauami	16°12' : 75°11'
Yadwad	16°15' : 75°11'
Harlapur	15°25' : 75°46'
Alur	15°15' : 75°45'
Haitpur	15°17' : 75°52'
Lakhundi	15°20' : 75°40'

Chanda district—

Nowergaon	19°55' : 80°00'
Somanapalli	19°38'30" : 79°39'00"
Dongangaon	19°37'00" : 79°40'30"

Ratnagiri district—

Phonda	16°23' : 73°43'
Kadawal	16°08' : 73°47'
Pangraed	16°08' : 78°49'
Hanumangarh	16°06' : 73°54'
Kasarda	16°26' : 73°42'

Satara district—

Phaltam	17°58' : 74°26'
Wakri	17°56' : 74°25'

MANIPUR

Limestone deposits were investigated by V. K. Raina (Roy, 1962) at Ukhrul (25°07' : 84°22'), Bundung (25°04' : 94°21'), Sokpa (24°59' : 95°16') and Toupokpi (24°14' : 93°54') in the Ukhrul sub-division.

The limestones are cherty and impregnated with calcite veins. They occur on hill spurs or in escarpment sections. The chemical analysis indicates that the limestone is suitable for cement manufacture. Further prospecting has been recommended.

Some limestone bands have been located recently in the Bisang series near Palel, Chepikarong and Sugnu in the Tenguipal sub-division. The grade and quality of these limestones are now being studied.

According to T. Banerjee (West, 1950) limestone is found in the following places :—

Near Ukhrul	Reserves : 200,000 tons (203,000 tonnes of limestone).
Near Lambut (25°01' : 94°17')	Reserves : 500,000 tons (508,000 tonnes) of limestone with 45.5 per cent of CaO.
Hungdung (25°04' : 94°03')	Reserves ; Two million tonnes of limestone with 52.9 per cent of CaO.
Taupokpi near Shuganu (24°18' : 93°53')	Reserves : 120,000 tons (122,000 tonnes) of limestone with 44.3 per cent of CaO.
Near Lamgang Khunou (24°24' : 94°04')	Reserves : 160,000 tons (162,000 tonnes) of limestone with 34.12 per cent of CaO.

REFERENCES

- Roy, B. C., 1962.—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, pt. I, p. 44.
 West, W. D., 1950.—General Report for 1948. *Rec. Geol. Surv. Ind.*, Vol., 82, pt. I, p. 61.

LOCALITY INDEX

	Latitude-Longitude
Ukhruh	25°07' : 94°22'
Bundung	25°04' : 94°21'
Sokpa	24°59' : 94°16'
Teupokpi	24°14' : 93°54'
Lambut	25°01' : 94°17'
Hungdung	25°04' : 94°03'
Sugaun	24°18' : 93°53'
Lamgang Khunou	24°24' : 94°04'

MYSORE

Bangalore district

Archæan limestones are reported near Chunchi in the Bangalore district.

Belgaum district

V. R. Venkoba Rao (Krishnan, 1958) reported the occurrence of thin bands of good quality, Lower Kaladgi limestones near Hoshatti ($16^{\circ}17' : 75^{\circ}18'$), Mannapur ($16^{\circ}18' : 75^{\circ}05'$), Arlimath ($16^{\circ}19' : 75^{\circ}06'$), Aurwan ($16^{\circ}19' : 75^{\circ}07'$) and Thimapur ($16^{\circ}15' : 75^{\circ}07'$) in the Gokak taluk, Belgaum district. They are described below :—

1. At 600 m. S. S. E. of Hoshatti occurs a band of pale grey limestone about 300 m. in length and 4.5-9 metres in width. It dips 45° - 55° towards the east.

2. A prominent band of limestone, bluish-grey to pinkish-white in colour occurs at 2.4 km. due east of Hoshatti in the form of an arc. The southern end of the arc extends in disconnected patches, for about 1.5 km, the beds dipping at 45° - 50° towards north. The northern end of the arc extends for about 6.5 km. in small disconnected bands, each band ranging in length from 23 to 61 metres and 7.6-23 metres in width, dipping southwards at 45° - 75° .

3. A band of limestone is traced in the form of an arc to the north-east of Mannapur. It runs for about 3.2 km. in small disconnected patches. The rock is bluish-grey in colour and dips towards the east and south at 30 - 40 degrees. Near Aurwad, a band of bluish-grey limestone, apparently connected with the Mannapur band, runs for about 500 m. and dips southwards at 35 - 45 degrees. It ranges in width from 45.7 to 68.5 metres.

4. A thin band of bluish-grey limestone, about 200 m. in length and 15 to 23 m. in width, occurs to the north of Thimmapur. It dips 60° - 70° towards north.

Representative samples of limestone, analysed in the Laboratories of the Geological Survey of India, give the following results :—

	1	2	3	4	5	6	7
SiO ₂ % . . .	1.00	3.42	2.23	2.96	4.21	2.81	2.56
R ₂ O ₃ % . . .	1.31	1.53	1.12	2.01	1.03	1.82	3.61
MgO% . . .	0.98	2.10	2.32	trace	0.85	trace	1.04
CaO% . . .	33.31	50.74	50.62	52.05	49.43	52.61	51.09
Loss on ignition % .	43.20	42.03	42.20	42.04	41.84	42.13	41.96

Localities—

1. 0.8 km. S. S. E. of Hoshatti
2. 2 km. E. S. E. of Hoshatti
3. W. S. W. of Mannapur
4. South of Mannapur
5. West of Aurwad
6. 0.6 km. to the N. N. E. of Thimmapur
7. 2.4 km. N. N. W. of Halki

Y. S. Sahasrabudhe (Krishnan, 1953, p. 45) reported the occurrence of crystalline limestone near Nagargali ($15^{\circ}25' : 74^{\circ}37'$). Krishnan (1954, p. 69) also reported fine saccharoidal limestone varying in colour from white to grey in the Mahadevi ravine between Bhimgad ($15^{\circ}35' : 74^{\circ}18'$) and Dar-singa ($15^{\circ}31' : 74^{\circ}17'$). It has a strike roughly NW-SE and dips gently towards the north-east.

V. R. Venkoba Rao (1951) noticed a few bands of good quality limestone near Yadwad ($16^{\circ}14' : 75^{\circ}11'$) and Manami ($16^{\circ}11' : 75^{\circ}11'$). They occur as intercalations in highly siliceous and cherty limestones of the Lower Kaladgi series. Four prominent bands are met with, two of them occurring near Yadwad and the other two near Manami. The bands extend from 0.8 km to 1.6 km in length and are 15 to 36.5 m. in width, showing at places a northerly dip of 35° to 60° . The rock is crypto-crystalline and bluish grey to light grey in colour. The quality of the rock differs at places owing to the presence of associated shales. The bands show a smooth and rounded surface in contrast with irregular and rough surface of the more siliceous and cherty bands. At present the limestone is being sporadically used for lime burning. Samples from different localities analysed in the Geological Survey of India Laboratory give the following results :

Analyses

	1	2	3	4	5	6
SiO ₂ %	2.18	0.93	2.14	1.18	1.51	1.69
Al ₂ O ₃ } R ₂ O ₃ %	1.01	1.02	1.40	1.10	0.40	4.40
Fe ₂ O ₃ }						
MgO %	7.28	0.52	6.22	trace	trace	4.28
CaO %	44.95	53.09	45.06	54.07	53.09	46.38
Loss on Ignition %	43.36	43.36	43.32	43.20	44.14	42.98

Localities—

1. 400 m. W. N. W. of Yadwad.
2. 400 m. S. S. W. of Yadwad.
3. Nala north of Yadwad.
4. 1.6 km. north-east of Manami.
5. 1.6 km. N. N. E. of Kunnal.
6. West of Tondikatti.

The analytical results show that some of the bands are suitable for the manufacture of cement.

According to B. Rama Rao and S. Varadarajan (1958) grey coloured limestone (CaO, 48.0 per cent; MgO, 2 per cent) occurs between 15th and 18th mile-stone on the Nagargali and Dandala road. The exposure is about 4 km. in length and 800 m. in width. The deposit has been estimated to yield 51 to 56 million tonnes to a depth of 7.6 m.

Bellary district

According to B. Rama Rao and S. Varadarajan (1954) there are only a few minor occurrences of limestone near Hoovinahadagalli, Harapanahalli and Birabigudda in the Bellary district. The occurrences being very small are not economically important.

A small deposit of calc-tufa is reported near Ettinapatti (15°08' : 76°37') and of *kankar* near Sandur.

Bijapur district

The important occurrences of the limestone in the Begalkot and Bilgimahal *taluks* were examined by S. Krishnaswamy in 1945. The following details are taken from his report:—

Begalkot (16°12' : 75°45') : The limestone bearing area is about 503 m. wide at its widest part, the limestone bands extending westwards for about 6 km. from a point of about 1.2 km north-east of the Begalkot railway station.

Analyses

	1	2	3	4
CaO %	46.73	47.72	42.75	48.58
MgO %	1.54	1.44	1.65	0.86
Insolubles %	11.64	10.50	14.75	8.90

Gadaukeri : This deposit commences in the east about 80 km. south of Haveli and extends for 6 km to the west upto the river Ghatprabha. The strip is about 6034 m. long and 401m. wide.

Analyses

CaO %	48.43	50.24
MgO %	3.45	0.72
Insolubles %	3.96	6.04

Bandini and Murnal : It is a small deposit of greyish white limestone in shales.

Devnal, Kundargi and Shirgun : The limestone bearing strip measures about 5303 m. long and 352 m. wide. The limestone becomes dolomitic towards the southern limit.

Analyses

CaO %	46.59	50.85
MgO %	4.71	1.87
Insolubles %	4.80	3.60

Kaladgi : The deposit is situated between Hire Sillikeri and a point to the west about three kilometres N. N. W. of Yeudigeri, and is the largest occurrence within the Kaladgi basin measuring roughly 5149 m. long and 352m. wide.

Analyses

CaO %	50.45	49.60	50.14	48.92	52.00	50.70	51.14	48.75	50.29	45.74	50.57
MgO %	2.10	2.97	3.33	3.26	2.17	2.39	2.03	5.00	2.82	4.50	1.45
Insolubles %	3.60	3.64	2.24	5.72	1.92	2.21	3.08	1.68	2.52	6.36	4.60

Khajjidoni : The strip is roughly 3960 m. long 329 m. wide, the limestone dipping usually 30°-40° towards E. N. E.

Analyses

CaO %	49.31	45.05
MgO %	3.26	0.10
Insolubles %	3.36	1.60

Chik and Hire Sillikere : Lying on the bank of a *nala* about 300 m. S. S. E. of the 70/1 mile-stone on the Belgaum-Kaladgi road, this strip is less than 200 m. in length and 30 m. in width.

Analyses

CaO %	51.93	54.69
MgO %	1.81	3.62
Insolubles %	4.60	54.69

Mudhol taluk : Recent mapping by B. C. Roy (1958) in the Mudhol taluk, has revealed the existence of extensive deposits of high grade limestone, suitable for cement and for chemical purposes. The high grade

dolomitic limestone may be used as a flux in the steel industry or for refractory purposes. The deposits are detailed below :

Chinch Khandi Budruck (16°15' : 75°18') : The deposit occurs in an area of about 1.2 sq. km., and over 46 million tonnes may be available within a shallow depth.

Jamogi Budruck (16°15' : 75°21') : The limestone bands have an E-W strike either with gentle or steep dips.

Pellur (16°14' : 75°19') : An elevated strip of country, about 3.2 km. long and 800 m. wide, is almost wholly composed of limestone, having an east-west strike and dipping at 45-50° towards the south or dipping vertically. The reserves are estimated at about 91 million tonnes.

Bamanoudni (16°12' : 75°17') : The limestone exposures cover an area of nearly 5 sq. km. The beds have a strike W.N.W.-E.S.E., dip vertically or at high angles. About 188 million tonnes are anticipated within a depth of 15 metres from the surface.

Muddapur-Timmapur (16°13' : 75°21') : In a zone about 1.6 km. in length and 800 m. in width, nearly 46 million tonnes are expected within a shallow depth. The beds have a strike N.W.-S.E. and dip 45° to 50° towards north-east.

Analyses

	Muddapur	Timmapur
SiO ₂ %	16.42	20.97
Al ₂ O ₃ %	1.29	1.52
Fe ₂ O ₃ %	1.76	1.68
MgO %	1.90	1.57
CaO %	42.65	33.22
Loss on ignition %	35.05	34.45

Chitrabhankot (16°13' : 75°23') : Over 91 million tonnes may be present in an area of 2.5 sq. km., within a depth of 15 m. from the surface. The bed generally have a strike N.W.-S.E. with usually high dips towards the south-west.

Chaudapur (36°11' : 75°22') : The limestone bands dip between S. S. W. and south-west at 60-80°. Nearly 91 million tonnes may be obtained within a shallow depth in an area of 2.5 sq. km. A sample on analysed as follows : 12.7 per cent SiO₂; 0.98 per cent Al₂O₃; 0.12 per cent Fe₂O₃; 0.68 per cent MgO; 47.48 per cent CaO and 37.6 per cent loss on ignition.

Khajjidoni (16°10' : 75°27') : The Midehi nala section from Khajjidoni to Kadarkop, with bands showing 30° to 70° dip southwards, will yield an enormous quantity of limestone. A sample on analysis gives the following results :—12.69 per cent SiO₂; 0.94 per cent Al₂O₃; 0.96 per cent Fe₂O₃; 1.80 per cent MgO; 45.54 per cent CaO and 37.45 per cent loss on ignition.

Varchagal ($16^{\circ}8' : 75^{\circ}21'$) : Extensive bands of limestone with intercalations of shales, dipping from 50° to 75° towards N.N.W., are exposed in the *nala* section and in the rocky ground in the vicinity of Varchagal. In a 1.6 km. long and 800 m. wide strip, over 45 million tonnes would be obtained within a depth of 15 m. from the surface.

Mallapur ($16^{\circ}09' : 75^{\circ}19'$) : In a strip 1.2 sq. km. in area between the Belgaum-Lokapur road and the village, about 46 million tonnes are likely to be present within a depth of 15 m. from surface. A sample on analysis gives 2.6 per cent SiO_2 ; 0.11 per cent Al_2O_3 ; 0.63 per cent Fe_2O_3 ; 2.24 per cent MgO ; 51.39 per cent CaO and 42.63 per cent loss on ignition.

Lakshanhutti ($16^{\circ}19' : 75^{\circ}21'$) : Around this locality, in a patch of about 400 m. in length and 400 m. in width, over 5 million tonnes may be anticipated within a shallow depth. The limestone is however dolomitic. An analysis shows the following results : 6.50 per cent SiO_2 ; 0.52 per cent Al_2O_3 ; 0.93 per cent Fe_2O_3 ; 19.72 per cent MgO ; 28.72 per cent CaO and 43.68 per cent loss on ignition.

Lokapur ($16^{\circ}9' : 75^{\circ}22'$) : Here the limestone bearing belt is 8.0 km. long and 1.6 km. wide, and is in fact the most important and accessible locality in the Mudhol area. The limestone and associated shales and slates have a strike ranging between W.N.W.—E.S.E. and N.W.—S.E. and dip highly towards the south-west. Over 20 million tonnes of limestones are likely to be present within 15 m. from the surface.

Analyses

SiO_2 % . . .	8.98	6.98	9.14	1.05	4.07	2.54	1.08
Al_2O_3 % . . .	0.32	1.43	1.01	0.12	0.91	0.60	0.25
Fe_2O_3 % . . .	1.22	1.72	0.94	0.69	0.84	1.36	1.23
MgO % . . .	1.08	3.75	0.39	trace	19.62	19.38	20.46
CaO % . . .	48.85	46.18	49.09	54.20	29.56	30.05	30.62
Loss % . . .	30.85	39.20	38.95	43.40	44.42	46.38	46.60

Localities :—

- (1) Chowdharimanya, Lokapur.
- (2) Bamanbudni *nala* 9.6 km. from Lokapur.
- (3) Lokapur.
- (4) *Nala*, north of Lokapur.
- (5) Lokapur
- (6) Lokapur
- (7) At the third mile from Lokapur on the Yadwad road.

Maddibihal taluk : V. R. Venkoba Rao (Roy, 1961) examined extensive deposits of pale-grey to cream and purple to pink, flaggy limestones belonging to the lower members of the Upper Bhima series around Kuchal ($16^{\circ}27' : 76^{\circ}00'$), Talikot ($16^{\circ}28' : 76^{\circ}0'$), Maileshwar ($16^{\circ}28' : 76^{\circ}20'$) and Salyadgi ($16^{\circ}27' : 76^{\circ}25'$). He reports that the beds, resembling the well known Shahabad limestones, are almost horizontally disposed or show a

very gentle northerly dip. The rock is fine-grained, compact and comparatively soft and appears to be of good quality.

Venkoba Rao collected 13 random samples from the different localities to find out their quality. The results of the chemical analyses are tabulated below :

Sample No.	SiO ₂ %	R ₂ O ₂ %	CaO %	MgO %	Loss on ignition %	Total %
1 . . .	4.84	1.15	51.83	0.98	40.66	99.46
2 . . .	7.16	1.20	51.19	0.91	39.72	100.18
3 . . .	17.82	1.90	44.37	0.62	34.98	99.69
4 . . .	9.38	1.70	49.84	0.62	38.26	99.80
5 . . .	7.48	2.80	50.42	0.72	39.02	100.44
6 . . .	5.76	1.70	51.70	0.62	40.22	100.00
7 . . .	17.08	1.70	44.04	0.62	36.72	100.16
8 . . .	8.40	0.50	50.02	0.62	39.03	98.57
9 . . .	7.00	1.70	51.06	0.36	39.48	99.60
10 . . .	8.76	1.10	50.02	0.36	39.82	100.06
11 . . .	7.02	1.10	50.81	0.62	39.91	99.46
12 . . .	11.12	2.00	48.37	0.80	37.71	100.00
13 . . .	5.40	6.50	41.55	1.16	44.89	99.50

Since several samples are of high grade, Venkoba Rao recommends that a systematic prospecting and sampling should be carried out to assess the quality and quantity of the limestone. According to him, the reserve would be of the order of three to five hundred million tonnes and might constitute an additional source of limestone for the Bagalkot cement factory situated in the vicinity.

According to P. N. Mukherjee (Krishnan, 1955) the Talikot deposit covers an area of about 16 km. by 1.6 km. The estimated reserves of the limestone near Talikot is about 300 million tonnes.

V. R. Venkoba Rao (Krishnan, 1958 a, p. 12) reported an occurrence of a pale grey, shaly and flaggy lower Kaladgi limestone at about 5 km. S. S. W. of Katgeri (16°04' : 75°39') in the Badami taluk. The rock, spreading over an area of nearly 2.5 sq. km, is interbedded with purple shales and dips gently towards north. A sample analysed in the G. S. I. laboratory showed that it contains 49.11 per cent of CaO and 0.69 per cent of MgO.

Chikmagalur district

Kankar occurrences are noted in the Kadur and Chickmagalur taluks.

Chitradurga district

According to A. N. Sen (1920) limestone occurs in the following areas :

1. *Javagondanahalli* : A discontinuous band of limestone runs for about 23 km. in a N.W.-S.E. direction starting from a point 6.4 km. north-east of Hiriur and about half way between the villages of Babbur and Maskal. The width of the band varies between 1 m. and 12 m. Quartz, felspar, epidote and iron oxide are present in variable quantities. The insolubles in four samples vary between 6.14 per cent and 18.59 per cent. Only one sample had insolubles more than ten per cent.

Near Kasavanhalli on the north bank of the Vedavati river about 2600 tonnes of limestone are estimated. Limestones occurring near Borakute, Gorladku and Javangondanahalli are of high calcium type and are mixed with calc-silicate rock. A sample of limestone from this area analysed 14.17 per cent insolubles.

2. *Jagalur taluk* : Impure limestones containing siliceous material and seldom exceeding six metres in thickness occupy a major part of the area. The dark grey crystalline limestone is compact and of the high calcium type.

3. *Hiriur and Hasdurga taluks* : The limestones in this area occur near Marikanive, Kuduvekanive, Maddakere, Lakkihalli and Mattod. Mainly two varieties of limestone occur (i) grey crystalline rock which is magnesian in composition and (ii) crystalline rock of the high calcium type often showing a banded character.

Limestone from the Marikanive area contain 8.25 per cent insolubles. The magnesian variety of limestones occur in abundance in the Maddakere area, the high calcium variety being localised in a few places analysing nearly 11 per cent insolubles on the average.

In the Kanchipur area, a total of about 3.4 million tonnes of high calcium variety of limestone containing insolubles less than 8 per cent has been estimated in detached outcrops. In the Kudure-Kanive State reserved forest area, 1.2 million tonnes of limestone have been estimated. The variation in the chemical composition of five samples is given below :

Insolubles %	R ₂ O ₃ %	CaO %	MgO %
1.14—11.84	0.74—4.67	32.01—50.20	1.55—17.2

Kankar is reported from the Hariur, Jagalur and Chitaldrug taluks. Samples from the Chitradurga district are reported to contain 34.4 to 49.8 per cent of CaO ; 0.3 to 5.9 per cent of MgO and 8.1 to 19.5 per cent of insolubles.

In sheet No. 57 C/5 mapped by the Mysore State Geological Department, a prominent strip of limestone has been demarcated 1.6 km. E of hillock Δ 2836 and Δ 2584 and nearly 3 km. south-west of Vanivilasapura (13°54'30" : 76°29'). The entire band covers a surface area of about 8 km. by 0.25 km. Another limestone exposure covering a surface area of about 8 km. by 120 m. is found 1.6 km. east of Kappanaikanahalli (13°46' : 76°26'), 800 m. west of Tarikera (13°47'30" : 76°26'30") and 1.5 km. west of Hindedevarahalli (13°48'45" : 76°26'45").

There are also several scattered small outcrops of limestone near hills Δ 2637, Δ 2442, 1.5 km. east of Δ 3078 ; 800 m. north-west of Pavilion

(13°53'30" : 76°29'), 3 km. west of Rangapanahatti (13°54' : 76°27'), 1.5 km west of Oddarahalli (13°56' : 76°28'45"), about 1.5 km. east of Gulihosahalli (13°58'30" : 76°22'30") and about 1.5 km. north-west of Lakkiahalli (13°05' : 76°27').

In sheet No. 57 C/6 (Mysore Geological Department; 1 inch=1 mile map) there are number of minor occurrences near hillocks Δ 2796, Δ 2906, Δ 2998, Δ 2748 and 1.6 km. west of Kaggalakatte (13°44' : 76°28').

Dharwar district

K. C. Channabasappa (Krishnan, 1954 p. 70) recorded the occurrence of two thin limestone bands each about 15 m. in width and extending for a length of over 1.6 km. in an east-west direction, about 3.2 km. north-west of Doni (15°17' : 75°43'). The bands dip 30-35° northwards. Thin bands of limestone are also noted to the south and east of Dindur (15°18' : 75°40'). The minimum reserves of limestone from all the deposits may be about 254,000 tonnes to a depth of 7.6 m.

According to Y. S. Sahasrabudhe (Roy, 1964) dark grey, fine-grained and compact crystalline limestone, interbedded with highly folded bands of hematite-quartzite (Dharwar), occurs in the low lying hill about 1.6 km. north of Chandanmatti (15°31' : 75°6'). Samples analysed gave the following results :

SiO ₂ %		17.66	19.28
R ₂ O ₃ %		2.25	4.30
CaO %		43.73	40.51
MgO %		0.69	1.27

As the reserves are limited, the limestone may meet only local demands.

Lumps of nodules of *kankar* are commonly found in the Regur covered areas of the Dharwar district. According to Y. S. Sahasrabudhe (Roy, 1962, p. 42) extensive spreads of *kankar* occurs in the black cotton soil areas, north of Lakshmeshwar (15°08' : 75°28'), near Yerebudihal (15°12' : 75°23') and Gudgeri (15°08' : 75°23'). It is being locally used for lime burning.

According to K. C. Channabasappa (Krishnan, 1953, p. 46), small quantities of *kankar* are worked for lime burning in the neighbourhood of Mukh-tumpur (15°11' : 75°43'), Bennihalli (15°10' : 75°53') and at Mundargi in the Dharwar district.

Gulbarga district

Surapur taluk : According to C. Mahadevan (1941), limestones belonging to the Upper Bhima series are exposed from about 1.6 km. west of Hebbal Khurd to Wajal, Devapur, Salvadgi, Rajan Kollur and Hagratgi. The limestones in the area show a fairly wide range of colour and other physical characteristics. The beds normally dip to the north from 2° to 5°. The chemical composition of the limestone shows that they are high in calcium, with magnesia and iron in negligible quantities.

Representative samples from all over the area were analysed by New berry's Volumetric method, and the results are given below :

Locality	MgCO ₂ %	CaCO ₃ %	Insolubles %	Remarks
Marlbavi . . .	1.1	92.0	6.9	
Gulbal plateau N. E. of Benkanhalli.	1.1	94.6	4.3	Calcite in association
Hagratgi plateau . . .	1.7	88.0	10.3	Cherts in association.
Devapur . . .	4.4	71.8	23.8	Much weathered.
Rajankollur . . .	1.1	85.8	12.1	Hard limestone.
Hagratgi . . .	4.2	64.8	31.0	Cherts in association.
Hebbal Buzurg . . .	1.2	89.4	9.4	Solution holes.
Wajal . . .	1.2	92.0	6.8	Ditto.
Kolipal . . .	0.5	84.8	14.7	Silky lustre.
Terth . . .	0.2	81.8	18.0	Cherts in association.

Hassan district

Limestone deposits are reported from Bettadpurbetta. *Kankar* patches are reported from Holenarsipur, Arsekere and Avkalgud taluks.

In sheet No. 57 C/8, mapped by the Mysore Geological Department, there are number of thin linear bands of limestone extending in a N.W.-S.E. direction associated with dark hornblende-schists. One continuous band of limestone occurs near the villages Averahalli (13°0'30" : 76°27'30"), Honnamaranahalli (13°0'45" : 76°28'), Mavinahalli (13°1' : 76°27'), Rangunahalli (13°3' : 76°26'30") and Kamamayakanahalli (13°4' : 76°26'30") covering a surface area of about 8 km. by 180m. Limestone outcrops are also noticed near Bhaktarahalli (13°5'45" : 76°25'45") and hillock Δ 2983. The Bhaktarahalli exposure covers a surface area of about 1.2 km. by 120m. ; other small isolated patches are found at 800m. SE of Gobalahalli (13°8'30" : 76°23'45"), 1 km. E of Golarahalli (13°14' : 76°19'30"), Agrahra (13°3' : 76°18'30") and 800m. S. W. of Manchenahalli (13°6'30" : 76°18')

Kolar district

According to B. Rama Rao and S. Varadarajan there are a few small deposits in the Kolar schist belt. Of these, a mention may be made of the occurrence at Sakarasahalli west of the Kolar gold fields. This deposit is associated with manganese occurrences and was worked on a minor scale by the Mysore Gold mining Co. during the years 1923 to 1927. The quality is reported to range between 25 and 28% CaO, 5.5 to 6.9 % MgO and 12 to 14% Mn.

Kankar is reported from Chikballapur.

Mysore district

B. Rama Rao and S. Varadarajan reported small lenticular magnesian limestone deposits, 0.8 to 1.2 km. in length and 122 to 152 m. in width. The prominent among these is about 5.5 km. (3.5 miles) west of Chattanahalli on the Mysore-Antharasante road. This deposit shows high calcium bands. The reserves are estimated at 100,000 tonnes. About 2.5 km. N.W. of the above deposit there are two more occurrences. The reserves from these to a depth of 6.1m. are estimated to be of the order of 1,000,000 to 1,500,000 tonnes. Apart from these, there are a few small occurrences 9.6—11.2 km. south of Saragur. These deposits, being small, are not economically important.

Archaeal limestone bands also occur near Heggudlu Sargur, Maduvanhalli, Kotekare and Bisavanbetta.

In Sheet No. 58 A/5, mapped by the Mysore Geological Department small limestone occurrences are located near the hill range Δ 3037, Δ 2779, Δ 2734 and about 800 m. north-west of Kanelalike ($11^{\circ}53' : 76^{\circ}25'15''$).

The important occurrences of *kankar* are in Gundlupet, Mandya, Mysore, Malvalli, Krishnarajpete and Hunsur taluks.

North Kanara district

According to B. Rama Rao and S. Varadarajan (1958) there is an occurrence of limestone in the Nagihavi pass south of Kulgi. Details of the deposits are not known. In a sample obtained from the eastern bank of Kalinadi, the quality ranges from high calcium to dolomitic type. Samples obtained from other area on analysis gave CaO 27 to 43 % and MgO 5.5 to 13.5%.

The Geological Survey of India have completed its first phase of investigation to locate suitable limestone bands by collection of groove samples across the limestone outcrops at critical places at the following localities :

Ganeshgudi ($14^{\circ}59' : 74^{\circ}36'$) ;

Setwade ($14^{\circ}57'30'' : 74^{\circ}34'30''$) ;

Barballi East ($14^{\circ}56'30'' : 74^{\circ}34'00''$) ;

Kodsalli ($14^{\circ}35'30'' : 74^{\circ}33'00''$) ;

Kalche NE ($14^{\circ}55' : 74^{\circ}34'$) ;

Kalche East ($14^{\circ}55' : 74^{\circ}34'$) ;

Kodlagaddo N ($14^{\circ}51'30'' : 74^{\circ}34'30''$) ;

Kodlagaddo S ($14^{\circ}50' : 74^{\circ}35'$) ;

Arballi ($14^{\circ}52' : 74^{\circ}39'$) ;

Castle Rock ($15^{\circ}24'00'' : 74^{\circ}20'30''$) ;

Shimoga district

According to B. Rama Rao and S. Varadarajan (1958), the main limestone band in the Shimoga schist belt extends in east-west direction from Ballur (Shikarpur taluk) to north of Arakere (Honalli taluk). Smaller deposits are found near Shankaragudda, N.N.W. of Kumsi, north of Bikonahalli Joladahalu, Rangapur, Malligere, Bhadigund, Gangur and Urbani. Of these, the Bhadigund deposit is mined to feed the cement factory at Bhadravati. The deposit contains certain dolomitic bands with more than 8% MgO. These are used as fluxing material in the Bhadravati Iron and Steel Works. This deposit was investigated by drilling in the past, and a reserve of 3,048,000 tonnes was estimated to an average depth of 24.4 m.

Kankar is reported from the Honnali and Sorab taluks. Highly calcareous chlorite schist, occurring in the middle of the nose of the Hosur anticline, east of Eltigehalli (14°14' : 75°25'), is traceable for a length of about 1.5 km. with a width of 1.2 km. and may be used locally for lime burning.

South Kanara district

According to A. Damodaran (Krishnan, 1954a, p. 109) shells are seasonally collected in the back-water regions near Mulki (13°06' : 74°47'), Udipi (13°20' : 74°45') and Coondapur (13°38' : 74°42') along the coast to the north of Mangalore.

Tumkur district

High calcium limestones occur near Voblapur containing upto 50% CaO. Other limestone occurrences in this district are at Dodguni, Chiknayakanahalli, Huliur and Nelanahalli.

In Sheet No. 57 C/10, mapped by the Mysore Geological Department the limestone beds generally show a north-easterly dip direction, with amounts varying from 40°-45°.

A strip of limestone occurs between Kandikere (13°13'30" : 76°37') and Agrahara (13°34'00" : 76°36'45"). The band covers an area 9 km. by 300 m.

Another band is recorded between Marahole (13°36'30" : 76°36'30"), and Gonadalu (13°37'30" : 76°36'00").

Limestone bands between Dodda Bayalakere (13°41'30" : 76°31'30") and Chikka Bayalakere (13°42'00" : 76°31'30") cover an area of 3.8 km. by 120 m.

Other minor occurrences are at about 1.6 km west of Gururahura (13°39' : 76°35'15") and 2 km. north-east of Gollarhatti (13°37'30" : 76°32'30").

In Sheet No. 57 C/11 (Mysore Geological Dept.; 1"=1 mile) three outcrops are demarcated.

The first band occurs near the hillocks Δ 2633 and Δ 3221, about 800 m. west of Yarekatte (13°26' : 76°42') covering approximately a surface area of about 10.8 km. by 1.6 km. The other band runs nearly 800 m. west of the hillock Δ 3489 and Δ 3459 and south of Δ 3439, covering a surface area of about 3 km. by 400 m. The third band is about 2 km. north-east of Hosanalli (13°26'00" : 76°38'30") and is exposed over an area of 7.5 km. by 600 m.

Minor occurrences are also noticed 1.6 km. east of Janahara (13°28' : 76°40') and near hills Δ 3279 and Δ 3509.

REFERENCES

- KRISHNAN, M. S., 1953.—General Report for 1950. *Rec. Geol. Surv. Ind.* Vol. 84, pt. I.
- , 1954.—General Report for 1951. *Rec. Geol. Surv. Ind.*, Vol. 85, pt. I.
- , 1954a.—General Report for 1952. *Rec. Geol. Surv. Ind.*, Vol. 86, Pt. I.
- , 1955.—General Report for the year 1946. *Rec. Geol. Surv. Ind.*, 79, pt. 2, pp. 807-808.
- , 1958.—General Report for the year 1953, *Rec. Geol. Surv. Ind.*, Vol. 87, pt. I, pp. 109-110.
- , 1958a.—General Report for the year 1953. *Rec. Geol. Surv. Ind.*, Vol. 88, pt. I.
- KRISHNASWAMY, S., 1945.—Investigation on limestone suitable for the manufacture of cement in the Begalkot taluk, Bijapur district (Unpublished.).
- MAHADEVAN, C., 1941.—Geology of the South-Western parts of Surapur taluk of Gulbarga district. *Jour. Hyderabad, Geol. Surv. Ind.*, Vol. 4 pt. I, pp. 132-135.
- RAMA RAO, B and S. VARADARAJAN, 1958.—Karnataka khaniza Nikshapagalu.
- REY, B. C., 1951.—Mineral Resources of Bombay, 1951.
- , 1958.—Mineral Deposits of the Kaladgi Basin. *Rec. Geol. Surv. Ind.*, Vol. 85, pt. 3, pp. 305-309.
- , 1961.—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, pt. I, pp. 115-116.
- , 1962.—General Report for the year 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, pt. I.
- SEN, A. N., 1920.—Limestone in parts of Chitaldrug district, Mysore. *Rec. Dept. Min. and Geol.* Vol. 19, pt. II, pp. 83-108.
- SONDHI, V. P.—Limestone deposits in India, their distribution, quality and extent pp. 46-50. (Unpublished.)
- VENKONA RAO, V. R., 1951.—*Rec. Geol. Surv. Ind.*, Vol. 85, pt. 3, pp. 309-310.

LOCALITY INDEX-

*Belgaum district—**Latitude—Longitude*

Hoshatti	16°17' : 75°18'
Mannapur	16°18' : 75°05'
Anlimath	16°19' : 75°06'
Aurwad	16°19' : 75°07'
Thimurapur	16°15' : 75°07'
Nagargali	15°25' : 74°37'
Bhimgad	15°33' : 74°18'
Darsinga	15°31' : 74°17'
Yadwad	16°14' : 75°11'
Manami	16°11' : 75°11'
Kunnal	16°05' : 75°10'
Tondikatti	16°5' : 75°10'

Bellary district—

Harapanaballi	14°48' : 75°59'
Ettinapatti	15°08' : 76°37'

Bijapur district—

Bagalkot	16°12' : 75°45'
Murnal	16°10' : 75°35'
Devnal	16°10' : 75°30'
Shirgupi	16°10' : 75°30'
Kaladgi	16°10' : 75°30'
Khajjidoni	16°10' : 75°27'
Chinch Khandi Budruch	16°15' : 75°18'
Jambgi Budruch	16°15' : 75°21'
Petlur	16°14' : 75°19'
Bemanbudni	16°12' : 75°17'
Muddapur-Timmapur	16°13' : 75°21'

LOCALITY INDEX—*contd.**Bijapore district—contd.**Latitude-Longitude*

Chitrabhankot	16°13' : 75°23'
Chandapur	16°11' : 75°22'
Varchagal	16°08' : 75°21'
Mallapur	16°09' : 75°19'
Lakshanhutti	16°19' : 75°21'
Lokapur	16°09' : 75°22'
Kuchal	16°27' : 76°00'
Talikot	16°28' : 76°00'
Maileshwar	16°28' : 76°20'
Salvadgi	16°27' : 76°25'
Katgeri	16°04' : 75°39'

Chikmagalur district—

Kadur	13°30' : 76°00'
Chikmagalur	13°15' : 75°45'

Chitradurga district—

Javanagondanahalli	13°51' : 76°40'
Jagalur	14°30' : 76°30'
Madsakera	13°50' : 76°20'
Lakkihalli	13°55' : 76°25'
Mattod	13°45' : 76°20'
Kanchipura	13°40' : 76°25'
Chitaldrug	14°10' : 76°20'
Vanivilasapura	13°54'00" : 76°29'30"
Kappanaikanahalli	13°46' : 76°26'
Tarikera	13°47'30" : 76°26'30"
Hindedevarahalli	13°48'45" : 76°26'45"
Pavilon	13°53'30" : 76°29'00"
Rangapanahatti	13°54' : 76°27'

Dharwar district—

Doni	15°17' : 75°43'
Dindur	15°18' : 75°40'

LOCALITY INDEX—*contd.**Dharwar district—contd.**Latitude-Longitude*

Chandanmatti	15°31' : 75°00'
Lakshmeshwar	15°08' : 75°28'
Yerebudihal	15°12' : 75°23'
Gudgeri	15°08' : 75°22'
Mukhtampur	15°11' : 75°43'
Bennihalli	15°10' : 75°53'

Gulberga district—

Surapur	16°30' : 76°45'
Devapur	16°25' : 76°30'
Salvadgi	16°25' : 76°02'
Rajan Kollur	16°20' : 76°25'

Hassan district—

Hole Narsipur	12°45' : 76°15'
Averahalli	13°00'30" : 76°27'30"
Honnamaranahalli	13°00'45" : 76°28'00"
Mavinahalli	13°01' : 76°27'
Rangunhalli	13°03'00" : 76°26'30"
Kamamayakanahalli	13°04'00" : 76°26'30"
Bhaktarahalli	13°05'45" : 76°25'45"
Gobalahalli	13°08'30" : 76°23'45"
Golarahalli	13°14'00" : 76°19'30"
Agrahara	13°03'00" : 76°18'30"
Manehenahalli	13°6'30" : 76°18'00"

Kolar district—

Chikballapur	13°25' : 77°40'
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Mysore district—

Chattanahalli	12°10' : 76°30'
Sorgur	11°55' : 76°20'
Maduvanahalli	11°55' : 76°30'
Kotekare	11°55' : 76°35'

LOCALITY INDEX—contd.

*Mysore district—contd.**Latitude-Longitude*

Kanelalike	11°53'00" : 76°25'15"
Mandya	12°30' : 76°50'
Mysore	12°15' : 76°40'
Malvalli	11°50' : 76°40'
Krishnarajpet	13°10' : 75°45'

Shimoga district—

Ballur	14°20' : 75°50'
Shankaragudda	13°50' : 75°25'
Kumsi	14°00' : 75°20'
Joladahalu	13°15' : 75°40'
Rangapur	13°50' : 76°05'
Malligere	13°25' : 76°25'
Gangur	14°05' : 76°00'
Honnali	14°10' : 75°35'
Sorab	14°20' : 75°05'
Eltigehalli	14°14' : 75°25'

South Kanara district—

Kulki	13°06' : 74°47'
Udipi	13°20' : 74°45'
Coondapur	13°38' : 74°42'

Tumkur district—

Chiknayakanhalli	13°25' : 76°35'
Nelanhalli	12°55' : 70°10'
Kandikere	13°13'30" : 76°37'00"
Sadavahalli	13°12'30" : 76°37'00"
Bairahingahalli	13°32'30" : 76°37'30"
Agrahara	13°34'00" : 76°36'45"
Marahole	13°37'30" : 76°36'00"
Dodda Bayalakere	13°41'30" : 76°31'30"
Chikka Bayalhere	13°42'00" : 76°31'30"

LOCALITY INDEX—*concd.**Tumkur district—contd.**Latitude-Longitude*

Gururahura	13°39'00" : 76°35'15"
Gollarahatti	13°37'36" : 76°32'30"
Yarekatte	13°26' : 76°42'
Hosanalli	13°26'00" : 76°38'30"
Janehara	13°28' : 76°40'

NAGALAND

Naga Hills district

T. Banerjee (Krishnan, 1953) reports the occurrence of thin encrustations of calc-tufa on the surface of calcareous sandstones in the Disang series near Tambu ($26^{\circ}30' : 94^{\circ}41'$), Changtongia ($26^{\circ}32' : 94^{\circ}41'$) and also in similar rocks of the Tipam series near Yachang ($26^{\circ}41' : 94^{\circ}32'$) and in some other places in the Naga Hills district. These occurrences are not of economic importance.

REFERENCE

KRISHNAN, M. S., 1953—General Report for 1951. *Rec. Geol. Surv. Ind.*, Vol. 85, pt. I, p. 66.

LOCALITY INDEX

<i>Naga Land—</i>	<i>Latitude-Longitude</i>
Tambu	$26^{\circ}30' : 94^{\circ}41'$
Changtongia	$26^{\circ}32' : 94^{\circ}41'$
Yachang	$26^{\circ}41' : 94^{\circ}32'$

NEFA

Lohit Frontier Division

B. Laskar (Roy, 1962), reported occurrences of white crystalline dolomitic limestones close to the plains in the Jaipani area ($27^{\circ}55' : 96^{\circ}16'$). The limestone beds have a total thickness of about 24 m. and extend laterally for about one kilometre along the scarp face.

Siang Frontier Division

B. Laskar (Roy, 1962) noted a thick sequence of grey argillaceous limestones and calcareous slates associated with the Gondwanas in the Dibang (Siang) Valley.

REFERENCE

Roy, B. C., 1962.—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, pt. I, p. 75.

LOCALITY INDEX

<i>Lohit Frontier Division—</i>	<i>Latitude-Longitude</i>
Jaipani	$27^{\circ}55' : 96^{\circ}16'$
<i>Siang Frontier Division—</i>	
Dibang Valley	$28^{\circ}10' : 95^{\circ}40'$

ORISSA

Dhenkanal district

K. S. Subramanian (Roy, 1962, p. 42) recorded the occurrence of a thin bed of limestone in the Gondwana rocks east of Sapuinali ($21^{\circ}6' : 84^{\circ}49'$). He also recorded that some of the Talchir shales weather into calcareous concretions which are burnt locally for lime.

Numerous pockets of *kankar* were recorded by M. N. Deekshitulu (Kriahnan, 1954, p. 111) near Bhejia ($21^{\circ}05' : 85^{\circ}18'$), Pangatira ($21^{\circ}8' : 85^{\circ}22'$) and Tinua ($20^{\circ}32' : 85^{\circ}28'$).

M. N. Deekshitulu (Krishnan, 1958, p. 99) noted that *kankar* which is fairly widespread in the Pallahara sub-division is used for calcining. The more important concentrations are located in the vicinity of Biranmunda ($21^{\circ}18' : 85^{\circ}16'$) and Chingudimunda ($21^{\circ}16' : 85^{\circ}14'$).

According to B. N. Jayaram (Roy, 1962, p. 26), *kankar* is found in the soil cap near Dhedurpal ($20^{\circ}52' : 84^{\circ}32'$), Arkhadud ($20^{\circ}48' : 84^{\circ}40'$) and Jhanimunda ($20^{\circ}46' : 84^{\circ}26'$) and is used locally for lime burning.

K. S. Subramanian (Roy, 1964) recorded a dark coloured, hard, fine grained calcareous rock to the north of Khamana ($20^{\circ}54' : 85^{\circ}11'$) where the Nandir *Jhor* turns from south to east. The exposure is about 120 m. long and 60 m. thick on an average. A sample analysed 31.11% CaO and 1.58% MgO with 32.70% insolubles.

Ganjam district

Y. G. K. Murthy (1946-48) recorded *kankar* occurrences near Parlakimidi ($18^{\circ}47'00'' : 84^{\circ}05'30''$), Jilluba ($19^{\circ}49'00'' : 84^{\circ}39'19''$), Jillundi ($19^{\circ}54'30'' : 84^{\circ}34'15''$), Ghudadandi ($19^{\circ}54'30'' : 84^{\circ}32'30''$), Varanasi ($18^{\circ}51'00'' : 83^{\circ}53'30''$), Musiliguda ($18^{\circ}52'30'' : 83^{\circ}54'10''$), Salkaliguda ($18^{\circ}52'00'' : 83^{\circ}54'30''$), Jivanadasuguda ($18^{\circ}52' : 83^{\circ}54'$), Luhagudi ($19^{\circ}27'45'' : 84^{\circ}20'45''$), Bandaguda ($19^{\circ}28' : 84^{\circ}19'15''$), Talasingi ($19^{\circ}25' : 84^{\circ}20'45''$), Murmuria ($19^{\circ}25'15'' : 84^{\circ}19'$), Govindopur, Gochigiru ($19^{\circ}29' : 84^{\circ}20'$), Venkatrayapur ($19^{\circ}28'00'' : 84^{\circ}53'15''$), Adaba ($19^{\circ}29' : 84^{\circ}11'$), Kandhaba ($19^{\circ}27'30'' : 84^{\circ}12'00''$), Badarasingi ($19^{\circ}28'00'' : 84^{\circ}14'30''$), Mohana ($19^{\circ}26'30'' : 84^{\circ}16'00''$), Ekasingi ($19^{\circ}9'30'' : 84^{\circ}48'00''$), Haradanga ($19^{\circ}11'00'' : 84^{\circ}46'20''$), Kurlanda ($18^{\circ}50' : 84^{\circ}3'$), Kurlandaguda ($18^{\circ}51'00'' : 84^{\circ}2'00''$), Bonnidiguda ($18^{\circ}51'00'' : 84^{\circ}1'30''$), Khariguda ($20^{\circ}03' : 84^{\circ}30'$), Khondikuti ($20^{\circ}2' : 84^{\circ}27'$), Gohribadi ($20^{\circ}30' : 84^{\circ}30'$), Rombha ($20^{\circ}05' : 84^{\circ}29'$), Dodaralunda ($20^{\circ}04' : 84^{\circ}30'$), Gurabadi ($19^{\circ}56'30'' : 84^{\circ}31'00''$), Repitupalli ($19^{\circ}55'30'' : 84^{\circ}29'00''$), Golia ($19^{\circ}46'30'' : 84^{\circ}49'30''$), Kusapalli ($19^{\circ}47' : 84^{\circ}51'$), Maraipalli ($19^{\circ}47'00'' : 84^{\circ}50'30''$), Nagiri ($19^{\circ}52' : 84^{\circ}44'$), Mundigarh ($20^{\circ}00'30'' : 83^{\circ}41'00''$), Sasarga ($20^{\circ}1'30'' : 83^{\circ}40'00''$), Kundutuli ($20^{\circ}10' : 84^{\circ}1'$), Nuagam ($20^{\circ}08' : 84^{\circ}11'30''$), Siritiguda ($20^{\circ}06' : 84^{\circ}15'$), Venkatrayapalli ($19^{\circ}27'30'' : 84^{\circ}43'30''$) and Onderagada ($19^{\circ}18' : 84^{\circ}15'$). Most of the material is used locally for making lime.

He also recorded calc-tufa occurrences near Kerama ($20^{\circ}17'30'' : 83^{\circ}51'00''$), Kurkelka ($20^{\circ}18'30'' : 83^{\circ}50'00''$), Dhanupatta ($19^{\circ}20' : 84^{\circ}18'$), Sinkulipadar ($19^{\circ}18'00'' : 84^{\circ}12'30''$), Rampathar ($20^{\circ}34'00'' : 84^{\circ}22'30''$), Sakari ($20^{\circ}22' : 84^{\circ}28'$), Magamunda ($20^{\circ}20' : 84^{\circ}11'$). These are very small and are not of any economic importance.

Keonjhar district

M. N. Deekshitulu (Krishnan, 1954) recorded *kankar* near Kauntalsuan ($21^{\circ}14' : 85^{\circ}27'$) and Sanda ($21^{\circ}13' : 85^{\circ}18'$). Near Sanda the nodules are large in size, being 5 to 7.5 cm. in diameter.

Koraput district

A. K. Dey (officers of G.S.I., 1949) recorded limestone deposits of Cuddapah age in the vicinity of the Sabari river, 30 km. west of Malkhanagiri, about 5 km. west of Kottametia ($18^{\circ}20' : 81^{\circ}42'$). They extend for about 2 km. along the bank of the river. These beds of light grey and cream coloured limestone vary from 3 to 6 m. in thickness, and are either horizontal or dip at a very low angle. The limestone from Kottametia is of an excellent quality as can be judged from the following analysis :—

SiO ₂	.	.	.	.	.	.	.	.	.	.	1.84%
R ₂ O ₃	.	.	.	.	.	.	.	.	.	.	1.24%
CaO	.	.	.	.	.	.	.	.	.	.	53.36%
MgO	.	.	.	.	.	.	.	.	.	.	0.59%
CO ₂	.	.	.	.	.	.	.	.	.	.	42.59%

South of the deserted village of Nandivada ($18^{\circ}19' : 81^{\circ}40'$), the limestone bands are dark grey and argillaceous for a distance of 1.2 km. beyond which they become interbanded with phyllites.

Argillaceous limestones associated with purple shales and slates, occur along the Kolab river near Guptesvara ($18^{\circ}49' : 82^{\circ}10'$) and Sirivada ($18^{\circ}50' : 82^{\circ}10'$). Near the roadside, about 2 km. north-east of Guptesvara, a band of more or less argillaceous limestone which occurs associated with shales, has been traced for a distance of 400 m. along its strike.

Deposits of limestone occur at Kondajodi ($18^{\circ}57' : 82^{\circ}15'$). The limestone bands are associated with purple and white Cuddapah shales and occupy small isolated hills. The strike varies between N.E.—S.W. and E.N.E.—W.S.W. and dip steep. Some of the outcrops could be traced over a distance of 3 km. along the strike. The limestone appears to be dolomitic and grades into shale. Limestones are locally used on a small scale for the manufacture of lime. A sample shows : 14.72% insolubles ; 0.20% R₂O₃ ; 25.35%, CaO ; 18.19% MgO and 39.3% loss on ignition.

Mayurbhanj district

S. V. P. Iyengar (Roy, 1961, p. 112) recorded the occurrences of *kankar* along the banks of *nalas* and gullies to the south of Manda ($22^{\circ}5' : 86^{\circ}14'$)—Bisai ($22^{\circ}10' : 86^{\circ}25'$) road, and to the west of Kusumbandh ($22^{\circ}6' : 86^{\circ}30'$) and in the area lying between Baldiha ($21^{\circ}58' : 86^{\circ}38'$) and Kuchai ($22^{\circ}0' : 86^{\circ}43'$).

Puri district

P. Perraju (Roy, 1962) suggested that *kankar* deposits near Koska (20°21' : 85°01') and Kharagprasad (20°22' : 85°01') may be used locally for lime burning. He (1958) also reported the occurrences of *kankar* around Ghantulibania (20°21' : 84°48'), Gorimara (20°16' : 85°00'), Barapalli (20°21' : 84°50'), Sirirampur (20°21' : 84°51'), Chillpathara (20°24' : 84°45') and Khajurdhei (20°25' : 84°54').

Sambalpur district

According to V. S. Krishnaswamy (1955), the limestone deposits of this district occur in the following areas :—

The Dungri-Banjipali, Lakhanpur and Launsara-Tamdei, deposits are on the south and south-east of the Mahanadi and are accessible from the town of Bargarh. Portion of the deposits of these areas must have been inundated by the Hirakud reservoir.

Dungri (21°42' : 83°34')-*Banjipali* (21°38' : 83°30')—Limestone occurs in a strip of plain country, about 13 km. long and 1.5 km. wide near the villages of Dungri, Sauntmal, Badmal, Behera, Kusumda and Banjipali. The limestone is interbedded with shales, sandstones and quartzites and the dips vary from 5° to 35°. In general, the thickness of the limestone horizon in any single exposed section varies from 1-2 m. to 7-9 m. South of Badmal a thickness of about 30 m. was noticed. There is considerable thickness of alluvium in the area. Some of the analyses are given below :—

	Dungri	Badmal	Banjipali
SiO ₂ %	5.6	5.8	8.8
Al ₂ O ₃ %	0.05	0.06	0.01
Fe ₂ O ₃ %	0.71	0.80	0.39
CaO%	49.84	49.84	48.44
MgO%	0.39	1.15	0.72
Loss on ignition%	39.9	40.74	38.92

Lakhanpur (21°38' : 83°37')—Occasional outcrops of dolomite and limestone are found in the flat ground covered by alluvium over an area of 10 km. long and 3 km wide in the Lakhanpur valley. The limestone and dolomite beds along with associated shales and quartzites are folded into an asymmetrical, plunging syncline with a steep western limb. The thickness of the horizon is of the order of 3 m. Bands of limestone, with low magnesia but high insolubles were located at 400 m. west of Darlipalli (21°39'00" : 83°36'30"), 600 north of Tillaimal (21°39' : 83°37').

Launsara (21°43' 30" : 83°35'00")-*Tamdei* (21°43'30" : 83°35'30")—Beds and intercalations of limestone in a shale formation which overlie the quartzites of the north hill of Tamdei are exposed in the bed of the Mahanadi river and near its right bank. In the strike continuation further SE. towards Launsara the lime

stone is hidden under a thick alluvial cover. The formations have moderate to low dips. The available analyses indicate that the limestone is either dolomitic with moderate to high insolubles or with high insolubles and low magnesia.

Sundergarh district

Limestone and dolomites form an important horizon in the rocks of the Gangpur area and have been classified by Krishnan under the Birmitrapur stage of the Gangpur series. The average width of the band varies between 609 m. and 761 m. of which dolomite forms nearly 364 m. to 457 m. and the limestone about 245 m. to 300 m. The general strike of the bands varies between E—W and E.N.E.—W.S.W. except at Lifripara where it changes to W.N.W.—E.S.E. The dip is generally steep (60° — 90°), but between Lanjiberna and Kinjirma, the bands show low dips of 30° to 50° . The limestone is fine to medium-grained and grey in colour. At times, the limestones are intimately mixed with siliceous and phyllitic material. In mineral composition, the rocks show all stages of transition from a pure crystalline limestone to calcareous phyllites and mica schists. Bands of tremolitic marbles are common at Dublabera, Purkapali, Kinjirma and Birmitrapur. About 50% of the outcrops in the area carries good quality material suitable for lime burning, cement manufacture, for flux and furnace lining, for uses in rubber, paper and allied industries. The lime content in the rock varies between 30% and 52%, with insolubles and silica upto 30% to 35% and with magnesia upto 15%. Alumina and iron oxide (combined) are never more than 6% to 8%. About one third of the limestone reserves in the area is suitable for fluxes and for cement manufacture. In the Gangpur limestone with the increase of insolubles and silica, there is no corresponding increase in the percentage of magnesia. This makes it possible for many of the slightly impure silica rich bands to be utilised for blending with good material to suit the requirements for flux and cement.

The outcrops of limestones are distributed mainly in two horizons along (1) the northern and (2) the southern limbs of the anticlinorium. In the northern part, outcrops occur at Raiboga, Birmitrapur, Hathibari-Gatitangar and along the *Katma nala* and the Deo river. In the southern part, the belt is extensive and outcrops occur over a distance of more than 96 km. between Jaraikela, Panposh, Lanjiberna and Kinjirma.

Description of the deposits.—Narayanswamy (1957) described the limestone belt as follows :—

1. Hathibari-Purnapani-Gatitangar-Katma nala belt :

Exposures of limestones occur at a number of places in the plain country 9.6 to 16 km. east of Birmitrapur, occurring over an area of 12.8 km. by 8 km. between Kokerama and the Deo river. An area of 40 hectares to the north and north-east of the Hathibari village contains both limestone and dolomite. Exposures of limestones are seen at two places (1) over an area of 200 m. by 120 m. forming the hillock north of Bajnathpur and (2) for a total width of nearly 42 m. along the *nala* 400 m. west of above.

The whole width of the limestone in the Bajnathpur hill is of flux-grade containing less than 6.5% insolubles and below 3.5% magnesia. The outcrops along the *nala* to the west show a high admixture of impure band but a major part is good.

Reserves.—The probable minimum reserves of flux-grade limestone for the exposed portions in the Hathibari area is around 1.5 million tonnes down to a depth of 30 m.

Section	Dimensions 30 metres depth basis	Reserves in tonnes
1. Bajnathpur hill	200×120×30 m.	1,300,000
2. <i>Nala</i> zone 300 m. west of above	76×42×27 m.	157,500

The reserves of the entire Hathibari area are estimated at 2.5 million tonnes.

Purnapani Block.—The band of limestone appearing at Hathibari continues eastward for 4 km. upto the Deo river passing through north of Purnapani. The western portion of the deposit extending for a length of nearly 1.5 km. between the Hathibari quarry and Pahartoli (800 metres north-east of Purnapani) forms the Purnapani block. The eastern part of the band cropping out for a length of about 1.5 km. from 400 m. south-west of Tikantoli upto the Deo river constitutes the Gatitangar block. The quality of limestone is similar to that of the Hathibari block. The total width of the limestone zone in the Purnapani block is about 300 m. to 365 m. of which the northern 180 m. carries bands of apparently good quality limestone while the southern 150 m.—180 m. shows banded limestone with thin phyllitic partings. The dip of the bands is about 70°-80° towards E.S.E. After an interval of about 0.2—0.3 km. to the east, six to seven outcrops of banded but visibly good limestone, each 9 to 15 m. by 3 to 9 m. are exposed along the *nala* 300 m. north of Purnapani. The total exposed width of the limestone zone here is about 300 m.

• From the analyses of the samples, it is seen that the Purnapani limestones are low in magnesia, the percentage of MgO in the majority of the cases being below 3.5 to 4% and in about half the samples below 2.5%. There are admixtures of impure siliceous bands. About 4/7 of the samples show insolubles and silica below 6.5%, 1/7 between 6.5% and 10% and in the remaining 2/7 above 10%. The bands are of varying composition, some suitable for both flux and cement; and some are slightly impure, suitable only for blending with good quality limestone either for flux or for cement. The rest are very impure.

Extent and Reserves.—Limestone suitable for flux extends over a zone of 1220 m. in length along the northern part of the area. The width of this zone is about 210 to 240 m. including a couple of impure bands 9 to 24 m. in width. Out of this, the minimum width of the flux-grade limestone will be about 120 m. The weighted average composition shows that the area is best suited for flux.

The area is only partially proved and there is every likelihood of this good quality zone continuing for a width of 60 m. eastwards for at least another 600 m. Much of the area along the southern part of the area is soil covered and unexplored.

Taking a minimum length of 1220 m. and width of 120 m., the probable reserves of flux-grade limestone from this area is 7.3 million tonnes upto a depth of 30 m.

Pahartoli barren zone.—About half a dozen outcrops of banded limestone are scattered around Paharatoli. From the presence of extensive outcrops in the Purnapani area to the west and in the Gatitangar area to the east, it is presumed that limestone extends into this region but under a thick overburden of limestone with less than 5% silica, 91 to 106 m. width with 5% to 8% silica and the rest containing 8% to 25% silica. The alumina and iron oxide in good quality bands are generally low averaging between 0.5% and 1.5%. The magnesia content in the flux-grade bands generally ranges between 2% and 4%.

Reserves.—According to V. P. Sondhi (1958), the probable reserves of limestone with less than 8% insolubles within a depth of 60 m. are about 100 million tonnes. The reserves with insolubles 8–25% are 63 m. tonnes.

The deposits are being worked by M/s. Bisra Stone and Lime Co. Ltd. (Bird & Co.).

Dublabera : (22°18': 84°38').—According to Muktinath the limestone formations occur in a syncline forming prominent hillocks east of Dublabera. Limestone is confined to the eastern slope of the hillock east of Dublabera, at the top of the hillock north-east of Dublabera and on the southern slope of the hillock south of Saromohan. The dip of the limestone is about 25°. This limestone deposit is confined to an area of about 305 m. × 120 m. Assuming that an average thickness of about 2.5 m. consists of good limestone, the deposit may yield 163,000 tonnes. Almost all of the 15 samples analysed contain more than 9% of SiO_2 .

Lanjiberna.—According to Muktinath the deposit is situated to the north of Lanjiberna (22°15': 84°30'). The limestone has a strike trending approximately east-west and dips 60° to 70°.

The southern belt consists of good limestone suitable for the manufacture of Portland cement. In the western side of this belt, the limestone is exposed within a zone of 305 m. × 106 m., the southern 9.1 to 12.2 m. of which is dolomitic (SiO_2 —0.48%; R_2O_3 —2.11%; MgO —5.14%; CaO —48.02%; Loss on ignition—43.66%.) Further to the east of this zone, the limestone is exposed for a distance of 152 to 183 m. with a width of 30 to 46 m. To the south of this exposure, the limestone is covered by alluvium and is of poor quality. In the central part of this belt, outcrops are scanty.

The limestone is grey to dark grey in colour and usually medium grained in texture. From the chemical analysis, the greater part of the area seems to be occupied by limestone suitable for cement. Out of 69 samples analysed 27 contain less than 5% of SiO_2 .

Gatitangar block.—In the Gatitangar area, limestone is exposed for a length of about 1225 m. The width of the limestone is about 410 m. in the area between Tikamtoli and Kijurtoli and nearly for 820 m. along the bed of the Deo river. The general strike of the bands is nearly east-west in the western half and gradually changes to E.N.E.—W.S.W. in the eastern part. The dip of the beds is about 75° to 85°. A small finely banded limestone with phyllitic partings occurs south-west of Tikamtoli. Bands of limestone (1) 120 m. by 12 m.—24 m. (2) 120 m. by 30 m. also occur to the N.N.W. of Kijurtoli at a distance of 30 to 37 m. to the north of the above.

The Gatitangar limestones are fairly low in silica. The SiO_2 in 2/3rds of the samples is below 5% and in the rest it ranges from 5%—8.6%. Magne-

sia is below 3.5% in half the number of the samples from the Pahartoli area, and between 3.5% and 6.5% in the remainder. The majority of the samples from the Deo river shows MgO below 3.5%. About 1/3 to 1/4 of the width appears to be suitable for flux and cement and of the remaining, at least 1/3rd of the width is of a quality suitable for blending with flux-grade limestone. The good quality limestone occurs as fairly broad bands. 9 to 24 m. in width, alternating with blending-quality or impure limestone.

Reserves.—In the Tikamtoli outcrop zone, the aggregate width of flux and cement-grade limestone is about 110 m. The aggregate width suitable for blending with flux-grade limestone is about 84 m. Taking an approximate length of 1220 m. along the strike from the south-west of Tikamtoli upto the Deo river and assuming that only 50 per cent is workable, the possible reserves of limestone from this area is around six million tonnes up a depth of 30 m. with an average overburden of 1.5 m. Out of this reserve the flux and cement grade limestone amounts to 3,474,000 tonnes and the blending quality amounts to 2,653,000 tonnes.

Birmitrapur.—The deposit at Birmitrapur is the largest in Gangpur and is the major source for flux-grade limestone in eastern India. The limestone occurs over a total distance of 6.4 km. with a width of 228 to 244 m. The general strike of the limestone band is east-west and the average dip is about 60° to the north.

The limestone occurs as broad bands of almost pure quality, alternating with bands of shale, phyllites and quartzite. The detailed sampling of the deposit has revealed a minimum aggregate width of at least 45 to 60 m. The northern belt runs parallel to the southern and is separated by a belt of dolomitic limestone whose width varies between 152 m. and 244 m. The outcrops are widespread in the eastern, central and western parts of the deposit. Groove samples were taken across the strike of the beds. 38 samples were collected and analysed.

A greater number of samples (26 out of 38) show SiO₂ ranging between five and six per cent and magnesia below 2.5%. Such limestones may be considered suitable for flux and cement. There are a few samples which are high in insolubles and low in magnesia and may be blended with good quality limestone for the manufacture of cement. Near the junction of the limestone with the dolomite and dolomitic limestone to the south, the limestone is slightly high in magnesia but low in insolubles. This may be blended with limestone low in magnesia and utilised for flux.

Reserves.—The reserves of limestone in the two belts of Lanjiberna area are of the order of 16 million tonnes.

Katang : (22°14' : 84°29').—Limestone is traceable along the strike for a distance of 730 m. The width of limestone and dolomite bands is about 300 m. The general dip is 50°-60°. In the southern side of the eastern part, limestone is interbedded with dolomite.

A study of the analyses indicates that the limestone in the eastern part of the quarry is suitable for the manufacture of cement. Out of 12 samples analysed, six showed SiO₂ below 5%.

Khatukurbahal : (22°17' : 84°29').—Here the limestone deposits are scattered. About 800 m. E.N.E. of Khatukurbahal there are few additional outcrops of limestone. The general strike is east-west dipping 85° to 60° northwards. The southern part of the deposit contains good quality

limestone but in the northern side it is dolomitic. The quality of limestone and dolomite along with their width as exposed in a *nala* west of the village is as follows :—

From south to north :

Exposures	Width	Insolubles	MgO	Al ₂ O ₃
		11.6%	2.7%	0.81%
Medium-grained limestone .	11.80 m.			
Rock not exposed	85.00 m.			
Impure limestone and dolomite .	18.30 m.			
No exposure	67.60 m.			
Dolomitic rock	18.30 m.			
Limestone	0.90 m.			
No rock	79.00 m.			
Dolomite	42.30 m.			

Assuming that a total thickness of about 38 m. of limestone in the southern side of the deposit is of good quality, and that it runs for a distance of 800 m. under an average overburden of 3 m., the reserves are of the order of 2.0 million tonnes within a depth of 30 m.

Analyses of limestone from Khatukarbahal are given below :—

Width of outcrop .	4.8 m.	8.2 m.	3.3 m.	16.1 m.	4.6 m.	12.2 m.
SiO ₂ %	11.88	6.44	5.58	7.32	4.38	9.44
R ₂ O ₃ %	3.80	2.52	2.60	2.40	3.20	3.80
MgO%	4.12	0.52	0.62	Trace	1.12	2.14
CaO%	42.53	49.70	50.60	49.90	49.49	46.24
Loss on ignition% .	37.32	40.34	40.48	39.68	41.34	38.40

Ludhukutoli (22°15' : 84°25').—Limestone is exposed just west of the Ludhukutoli village. The limestone bands have a strike approximately east-west, dipping 35° to 40° northwards. Five shallow trenches were made and 33 samples were analysed. The SiO₂ content is more than 5% and varies from 4.50 (only one) to 26.26%. The MgO content is generally below 3%.

Considering a thickness of 45 m. over a length of 720 m., the reserves are estimated to be about two million tonnes of stone with an average insolubles content of 10% to 11%.

Kandaimunda (22°14' : 84°26').—Flaggy limestone containing tremolite and pyrites is traceable for about 2 km. with a maximum width of about one kilometre. Poor grade limestone occurs west of Tiklipara. The entire deposit at Kandaimunda appears to be of poor grade for any consideration.

Kukurphuka ($22^{\circ}12' : 84^{\circ}30'$).—The deposit occurs about 8 km. northwest of the Sanakhan railway station and forms a part of the southern limb of the Gangpur anticlinorium. The limestone bands are exposed in the cultivated fields, *nalas* and over small hillocks. The exposures are abundant north of Gamhardih ($22^{\circ}12' : 84^{\circ}30'$) but they are confined to a few outcrops only north of Turmura ($22^{\circ}12' : 84^{\circ}29'$) and Sialjor ($22^{\circ}12' : 84^{\circ}27'$).

The limestone bearing area is traceable from Gamhardih to Sialjor for a distance of about 6.5 km. with a width of about 610 m. The beds have a strike approximately east-west dipping 60° - 70° southwards. The deposit consists of limestone and dolomite, the limestone being mostly confined to the northern part and dolomite to the south. Prominent outcrops of limestone are seen on the small hillock occurring southwest of Kukurbhuka village. The hillock is about 245 m. long, 46 m. wide and 6 to 9 m. high and is exclusively made up of limestone. The limestone is dark, medium to fine-grained and flaggy and appears to be of poor quality. It may be used for lime burning.

Just north of Gamhardih, there is another outcrop of limestone (7.6 to 9.1 m. wide); one sample from this outcrop was found to contain SiO_2 —5.90%; R_2O_3 —2.34% and MgO —4.88%. This deposit is not very extensive.

Purkapali and Kaduapara.—The deposit is situated at Purkapali ($22^{\circ}10' : 84^{\circ}23'$), about 6.5 km. north-west of the Garpos railway station. The limestone bearing area is 1.6 km. long and 1.2 km. wide. The strike of the bands is approximately N.E.—S.W. and dips between 25° - 50° to the south-east. The rock is mostly exposed on an elevated land in the central part between Nerabahal in the east and Purkapala and Niapara on the west. The prominent exposures are confined to the northern slope of the elevated land. Limestone occurs as thin bands associated with phyllites and mica-schists and the thickness of the bands varies between a few centimetres to two metres.

The limestone is usually grey in colour and fine-grained in texture. At places coarsely crystalline, white marble with plenty of tremolite is also seen. Hard compact siliceous limestone with greenish tinge is also present.

Analysis of three samples are given below :—

$\text{SiO}_2\%$	28.42	20.74	30.78
$\text{R}_2\text{O}_3\%$	11.47	7.79	12.96
$\text{MgO}\%$	4.85	3.82	6.48
$\text{CaO}\%$	29.55	36.05	26.44
Total loss on ignition%	24.95	31.37	20.78

In the southern part there is another outcrop of compact crystalline limestone which was also sampled. It was found to contain insolubles above 30%. In other parts, the proportion of shale to limestone is still high and the quality of limestone is poor.

Kaduapara.—The limestone deposit at Kaduapara ($22^{\circ}9' : 84^{\circ}22'$) is situated south-west of the Purkapali deposit and probably the southwestern continuation of limestone bands seen on the footpath in the Kaduapara village and in the *nalas* around the village. The limestone bands dip at 30° to 40° to the south-east and are associated with phyllitic bands. The limestone is flaggy over the greater part.

REFERENCES

- GHOSH, A. M. N., 1949.—The Economic Geology of Orissa, pp. 85-93, *Govt. of Orissa Publication*.
- KRISHNAN, M. S., 1954.—General Report for 1952. *Rec. Geol. Surv. Ind.*, Vol. 86, Pt. 1, p. 111.
- , 1958.—General Report for 1953. *Rec. Geol. Surv. Ind.*, Vol. 87, Pt. 1, p. 99.
- KRISHNASWAMY, V. S., 1955.—Limestones of the Mahanadi valley, Sambalpur district, Orissa, for cement manufacture. *Rec. Geol. Surv. Ind.*, Vol. 84, Pt. 3, pp. 303-324.
- MURTHY, Y. G. K., 1946-48.—A note on the *kankar* deposits of Ganjam district, Orissa. G.S. I (Unpublished).
- NARAYANASWAMY, S., 1957.—Limestone and dolomite deposits in Gangpur, Sundergarh district, Orissa. *Bull. Geol. Surv. Ind. Ser. A*, No. 12.
- ROY, B. C., 1961.—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, Pt. 1.
- , 1962.—General Report for 1956. *Rec. Geol. Surv. Ind.*, Vol. 91, Pt. 1.
- , 1962.—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. 1.
- , 1962.—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. 1, p. 45.
- , 1964.—General Report for 1960.
- SONDHI, V. P., 1958.—Limestone deposits of India, their distribution, quality and extent. Manufacture and use of building lime in India. Symposium held at Rewa, 1958 National Building Organisation.
- Officers of G. S. I., 1949.—The Economic Geology of Orissa, Orissa Government Press Cuttack.

LOCALITY INDEX

Dhenkanal district—

Latitude-Longitude.

Sapuinali	21°06' : 84°49'
Bhejia	21°05' : 85°18'
Pangatira	21°80' : 85°28'
Tinua	22°32' : 85°28'
Biranmunuda	21°18' : 85°16'
Chingudimunda	21°16' : 85°14'
Dhedurpal	20°52' : 84°32'
Arkhaolud	20°48' : 84°40'
Ihanimunda	20°46' : 84°26'
Khamana	20°54' : 85°11'

Ganjam district—

Parlakimedi	18°47'00" : 84°05'30"
Illuba	19°49'00" : 84°39'15"
Illundi	19°54'30" : 84°34'15"
Ghudadandi	19°54'30" : 84°32'30"
Varanasi	18°51'00" : 83°52'30"
Musiliguda	18°52'30" : 83°54'10"
Salkaliguda	18°52'00" : 83°54'10"
Livanadasuguda	18°52' : 83°54'
Luhagudi	19°27'00" : 84°20'45"
Bandaguda	19°28'00" : 84°19'15"
Talasingi	19°25'45" : 84°20'45"
Murmunia	19°25'30" : 84°19'15"
Gochigiru	19°29' : 84°20'
Venkatrayapur	19°28'00" : 84°53'15"
Adaba	19°29' : 84°11'
Kandhaba	19°27'30" : 84°12'00"
Badarasingi	19°28'00" : 84°14'30"

LOCALITY INDEX—*contd.**Ganjam district—contd.*

Latitude-Longitude

Mohana	19°26'30" : 84°16'00"
Ekasingi	19°9'30" : 84°48'00"
Haradanga	19°11'00" : 84°46'20"
Kurlanda	18°50' : 84°03'
Kurlandaguda	18°51'00" : 84°2'30"
Bonnidiguda	18°51'00" : 84°01'30"
Khariguda	20°03' : 84°30'
Khondikuti	20°02' : 84°27'
Gohribadi	20°30' : 84°30'
Rombha	20°05' : 84°29'
Dodaralunda	20°04' : 84°30'
Gurebadi	19°56'30" : 84°31'00"
Repitupalli	19°55'30" : 84°29'00"
Golia	19°46'30" : 84°49'30"
Kusapalli	19°47' : 84°51'
Maraipalli	19°47'00" : 84°50'30"
Nigiri	19°52' : 84°44'
Mundigarh	20°0'30" : 83°01'00"
Sasaraga	20°1'30" : 83°40'00"
Kundutuli	20°10' : 84°01'
Nuagam	20°08'00" : 84°01'30"
Siritiguda	20°06' : 84°15'
Venkatrayapalli	19°27'30" : 84°43'30"
Onderagada	19°18' : 84°15'
Kerama	20°17'30" : 83°51'
Kurkelka	20°18'30" : 83°50'00"
Dhanupatta	19°20' : 84°18'
Sinkulipadar	19°18'00" : 84°12'30"
Rampathar	20°34'00" : 84°22'30"
Sakari	20°22' : 84°28'
Magamunda	20°20' : 84°11'

LOCALITY INDEX—*contd.*

<i>Keonjhar district—</i>	Latitude-Longitude
Kauntalsuan	21°14' : 85°27'
Sanda	21°13' : 85°18'
<i>Koraput district—</i>	
Kottametta	18°20' : 81°42'
Nandivada	18°19' : 81°40'
Guptesvara	18°49' : 82°10'
Sirivada	18°50' : 82°15'
<i>Mayurbhanj district—</i>	
Manda	22°5' : 86°14'
Bisai	22°10' : 86°25'
Kusumbāndh	22°6' : 86°30'
Baldiha	21°58' : 86°38'
Kuchai	22°0' : 86°43'
<i>Puri district—</i>	
Koska	20°21' : 85°01'
Kharagprasad	20°22' : 85°01'
Ghantulibania	20°21' : 84°84'
Gorimara	20°16' : 85°00'
Barapalli	20°21' : 84°50'
Srirampur	20°21' : 84°51'
Chillpathara	20°24' : 84°45'
Khajurdhei	20°25' : 84°54'
<i>Sambalpur district—</i>	
Dungri	21°42' : 83°34'
Banjipali	21°38' : 83°30'
Lokhanpur	21°38' : 83°37'
Darlipalli	21°39'00" : 83°36'30"
Tillaimal	21°39' : 83°37'
Launsara	21°43'30" : 83°39'00"
Tamdej	21°43'30" : 83°35'30"

LOCALITY INDEX—*concl'd.**Sundergarh district—*

Latitude-Longitude

Lifripara	22°6' : 83°49'
Kinjirma	22°00' : 84°06'
Birmitrapur	22°20' : 84°40'
Raiboga	22°25' : 84°50'
Hathiabari	22°25' : 84°55'
Iaraikela	22°05' : 84°35'
Pamposh	21°25' : 84°55'
Purnapani	22°30' : 84°40'
Dublabera	22°18' : 84°38'
Lanjiberna	22°15' : 84°30'
Katang	22°14' : 84°29'
Khatkurbahala	22°17' : 84°29'
Ludhukutoli	22° . 5' : 84°25'
Kandaimunda	22°12' : 84°30'
Gamhardih	22°12' : 84°30'
Turmura	22°12' : 4°29'
Sialjor	22°12' : 84°27'
Purkapali	22°10' : 84°23'
Kaduapara	22°9' : 84°22'
Nerabahal	22°11' : 84°23'
Niapara	22°10' : 84°22'

PUNJAB

Ambala district

G. N. Dutt (Krishnan, 1955) mapped the limestone occurrences between Malla ($30^{\circ}46' : 77^{\circ}0'$) and Dabsu ($30^{\circ}38' : 77^{\circ}9'$). These localities were originally investigated by M. R. Sahni and B. R. C. Iyengar during 1948-49 field season. The localities are as follows:—

Between Malla ($30^{\circ}46' : 77^{\circ}00'$) and Junpur ($30^{\circ}45' : 77^{\circ}01'$).—The former is being worked by the Bhupendra Cement Works, Kharag ($30^{\circ}44' : 77^{\circ}05'$). Limestone occurs as small inliers in the Subathus.

Between Ramsar ($30^{\circ}41' : 77^{\circ}06'$) and Mandi ($30^{\circ}40' : 77^{\circ}07'$).—Four disconnected patches of limestones are found along the strike.

Raina (1950) carried out detailed sampling of limestone deposits in the area between Tundapathar ($30^{\circ}45' : 77^{\circ}01'$) and Sherla ($30^{\circ}40'30'' : 77^{\circ}07'00''$) of which a survey was undertaken by M. R. Sahni and B. R. C. Iyengar during the field season 1948-49.

J. P. Srivastava (1958a) collected samples from the limestone deposits near Tundapathar-Sherla in Ambala district, for testing their suitability in the manufacture of calcium carbide. The reserves of limestone in these deposits have been calculated by previous workers to be of the order of 20 million tonnes.

All the limestones sampled occur in Ambala district between latitudes $30^{\circ}45'$ and $30^{\circ}40'$ and longitudes $77^{\circ}00'$ and $77^{\circ}08'$. The description of the deposits is given below:—

(a) *Tundapathar* ($30^{\circ}45' : 77^{\circ}01'$).—According to G. N. Dutt (1963) two bands of limestone, 12 and 18 m. thick respectively extend for a distance 800 m. Assuming that the band can be quarried to a depth 30 m. the bands should yield 2 million tonnes of limestone. Out of eight samples, five analysed less than 5 per cent SiO_2 . The range in composition of these five samples is given below:—

$\text{SiO}_2\%$	$\text{Al}_2\text{O}_3\%$	$\text{Fe}_2\text{O}_3\%$	$\text{CaO}\%$	$\text{MgO}\%$	Loss on ignition%
1.30—3.90	0.30—3.28	0.84—2.10	48.63—53.36	Trace—1.78	38.52—42.30

The average composition of eight samples is: SiO_2 -3.93%, Al_2O_3 -1.52%, Fe_2O_3 -1.55%, CaO 51.27%, MgO -0.50% and loss on ignition-40.59%.

The range in composition of 11 samples is given below:—

$\text{SiO}_2\%$	$\text{Al}_2\text{O}_3\%$	$\text{Fe}_2\text{O}_3\%$	$\text{CaO}\%$	$\text{MgO}\%$	Loss on ignition%
1.68—4.50	0.34—2.10	0.62—2.07	44.22—52.98	Trace—3.50	41.28—43.08

The average composition is SiO_2 -2.65%, Al_2O_3 -0.79%, Fe_2O_3 -1.30%, CaO -51.34%, MgO -1.02% and loss on ignition-42.04%.

(b) *Brun deposits*.—Thin bedded nummulitic limestone bands having an average thickness of six metres occur south-west of the village. Taking the workable thickness as 4.5 m. and a working depth of 90 m. over a distance of 1.2 km. the reserves are estimated at 1.2 million tonnes. Such bands are also found to the east of Sirmara, Barach and Bonulu. The variation in chemical composition of 13 samples of this limestone is as follows :—

Insolubles and SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Loss on ignition
8.50—36.14%	1.12—4.54%	2.13—6.45%	28.26—31.23%	0.72—5.89%	26.15—37.70%

(c) *Kharag (30°43' : 77°50')*.—A cement-grade limestone band in Kharag extends for 1.2 km. with an average thickness of 21 m. The analyses of samples from Kharag are as follows :

SiO ₂ %	R ₂ O ₃ %	CaO%	MgO%	Loss on ignition%
5.92	1.21	48.82	3.47	41.72
5.92	3.55	48.46	1.66	39.63

(d) *Ramsar (30°41' : 77°06')-Sherla (30°40' : 77°07')*.—A bedded limestone, over 30 m. thick, dips at low angles. Assuming a workable depth of 90 m. over a distance of 2 km. the reserves are estimated at 12.4 million tonnes. The analyses of limestone from the band are given below :—

SiO ₂	R ₂ O ₃	CaO	MgO	Loss on ignition
%	%	%	%	%
1.46	1.20	52.02	2.08	42.78
1.38	0.98	52.83	1.22	43.78
12.04	3.82	44.83	1.50	37.40
7.82	2.64	47.77	1.27	39.88
1.22	0.90	53.55	0.74	43.64

(e) *Concretionary limestone*.—Limestones occur in patches and lenticles in the Nahan sandstones in the following places :—

(1) A three metre thick band occurs at Junpur for a distance of 90 m.

(2) A four metre thick band occurs to the south of Dhapli Balku for a distance of 800 m.

(3) A three metre thick band is traceable for 60 m. south-west of Mataur (30°44' : 77°00').

(4) A three metre thick limestone band occurs over a length of 1.2 km. at Kajar.

The variation in chemical composition of five samples of this limestone is given below :—

Insolubles	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Loss on ignition
31.40—58.20%	2.55—6.65%	1.95—3.59%	13.46—27.77%	0.9—3.01%	12.20—28.50%

Raina (1953) described the following important occurrences of Nummulitic limestones :—

(f) *Dabsu* (30°44' : 77°20').—A band of Subathu limestone 30.5 m. thick is found south of peak 3015 with a strike N.N.W.—S.S.E. In the Ghaggar, in a cliff face north-west of Dabsu, another band, 18 m. thick, occurs about one kilometre from the former. The limestone is low in magnesia but is highly siliceous (about 30%). Taking the workable depth as 90 m., the thickness as 15 m. and a length of 135 m., the reserves work out at 844,000 tonnes of limestone.

(g) *Ambri* (30°43' : 77°30').—Here a 4.5 m. thick limestone band extends for 183 m. About 2.5 million tonnes of limestone are available here. A sample from this deposit show 12.65% silica; 6.9% iron and alumina; 2% magnesia and 42% lime.

(h) *Jhekroh* (30°43' : 77°54')—*Jabial* (30°42' : 77°6') deposits.—An outcrop of Subathu limestone of about six metre thickness occurs in the hill face near Jabial. Assuming an approximate length of 800 m., a workable depth of 90 m. and a thickness of six metres, the reserves have been estimated at about one million tonnes. The variation in chemical composition of the limestone from a total of 14 analyses is given below :—

Insolubles and SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
10.32—42.88%	5.60—9.60%	1.55—3.86%	23.94—43.35%	22.74—30.36%

Gurdaspur district

J. P. Srivastava (1951) reports that limestone occurs as boulders and pebbles in the bed of the Chakki river which flows along the border of Gurdaspur and Kangra districts, south-east of Pathankot (32°17' : 75°40'). The boulders are used for the manufacture of lime. The variation in chemical composition of five samples is given below :—

Insolubles and SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
3.80—33.50%	1.81—4.40%	Trace—4.50%	33.91—48.06%	28.12—37.80%

Thick limestone bands are interbedded with shales along the Pathankot-Dalhousie road from mile-stone 39 to beyond mile-stone 40.

The variation in chemical composition of six samples is given below :—

insolubles and SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
3.90—46.60%	0.60—4.14%	Trace—1.12%	27.45—51.7%	21.60—42.48%

A detailed prospecting is necessary to find out the quality and quantity of the limestones.

Gurgaon district

Kankar.—J. P. Srivastava (Roy, 1962 c) examined the reported occurrence of kankar in 112 villages in the Gurgaon district to assess their suitability for the manufacture of cement. In view of the lenticular nature of the deposits and the cover of alluvium the reserves cannot be assessed without systematic pitting, trenching or testing with hand auger. Srivastava has, however, on the basis of available data and local information, estimated a tentative reserves at 10.5 million tonnes, the details of which are as follows :

Gurgaon <i>tahsil</i>		2,255,000 tonnes
Nuh		223,500 „
Ballabhgarh		2,692,500 „
Palwal		5,410,000 „
TOTAL		10,550,000 tonnes

The chemical analyses of 12 samples collected show that majority of the samples are too high in insolubles (9.14 to 30 per cent). The MgO content varies from 1.55 to 3 per cent, except for two samples which show 9 and 12% MgO.

Hissar district

J. P. Srivastava (1958) examined the limestone quarries near Loharu (28°28' : 75°47'), and found a kankar layer, 50 to 90 m. thick, lying below the alluvium. These deposits are of lenticular nature, and the quality varies from hard to soft type.

Kankar occurs in lenticular beds below the alluvium between 28°24' and 28°31' north latitude and 75°54' and 75°45' east longitude in the villages Amirwas, Bairan, Bardu Chaina, Burdu Puran, Bisalwas, Gagerwas, Dhani Dhola, Sawansra, Phartia Bhima and Phartia Kahr.

Pitting and trenching are necessary for calculation of reserves.

Hoshiarpur district

B. M. Hukku (Roy, 1964) investigated the limestone deposits near Mohindpur (31°18' : 76°18'). The upper-Siwalik boulder conglomerates are overlain by sub-Recent terrace gravels towards the Soan river. The

latter are covered by the calc-tufa deposits at an approximate altitude of 380 m. above m.s.l. and extend downwards in the immediate vicinity of the steep topographic profile formed by the boulder conglomerates. A sample indicated less than 85 per cent calcium carbonate and it is, therefore, considered that the material is not suitable for use as chemical fertilisers.

Calc-tufa.—Detailed investigations of calc-tufa deposits in Birampur and Mohindpur were undertaken by the Geological Survey of India during the year 1961-62, for the Fertilizer Corporation of India, Naya Nangal. An area of 102,000 sq. m. was mapped on 1 : 1200 scale. Four trenches and 36 pits were put down and 53 channel samples were collected. As the extent is limited, the occurrence is not of economic importance.

Occurrences of calc-tufa have also been recorded at Khera Kaimot ($31^{\circ}17' : 76^{\circ}19'$) and Behra ($31^{\circ}16' : 76^{\circ}10'$), where the material is burnt locally for lime.

Kangra district

The Krol limestone near mile-stone 40 from Pathankot on the road to Dalhousie close to the Dundia Rest House ($32^{\circ}30' : 75^{\circ}55'$), was examined by Srivastava (1951) and samples were collected. These have yielded very good results, being particularly low in magnesia (1-12 per cent maximum) Srivastava recommends that this deposit should be investigated in detail.

B. N. Shukla and Srivastava (Roy, 1962a) have suggested that the calcareous tufa occurring as small concretions on the surface of the country rock near Sheobagh ($32^{\circ}00' : 77^{\circ}08'$) could be utilized locally for neutralizing the acidity of salt. The tufa is already being burnt locally for making lime.

An occurrence of calc-tufa has also been recorded at Nagni ($32^{\circ}18' : 75^{\circ}17'$) about five kilometres east of Nurpur and on the south-western flank of the Ramgarh ridge, east of Samlarah ($31^{\circ}41' : 76^{\circ}19'$).

Dharmkot district

Detailed investigation of the limestone deposits near Mcleodganj ($32^{\circ}14' : 76^{\circ}20'$) was carried out by Nautiyal, Dhoundial, Nadgir, DasGupta, and Ramchandra (1958).

The limestones occur in a narrow belt between two high angle thrusts trending N.W.—S.E., one on the southern side against the Dharamsala beds (Tertiary) and the other on the north-western side against the Darrang Traps and associated rocks. The calcareous zone (Para-autochthonous tectonic unit) is highly folded and many of the contacts are faulted.

The total reserves of cement grade limestone amount to about 16 million tonnes of which 15 million tonnes would come from the Dharmkot hill.

The limestone belt comprising pink, dark grey limestone dolomites and magnesian limestone and calcareous shales, occurs at Dharmkot ($32^{\circ}15' : 76^{\circ}19'$) near Dharamsala.

(1) *Pink limestones*.—This limestone is traceable from the north-east face of the Dharmkot hill to the Bal village and crops out at the following places :—

(a) *Bal ridge (From top of Bal to Bhated Khad)*.—The limestone bed dips 50° to 70° westwards. The reserves of cement grade limestone

have been estimated at one million tonnes. The variation in chemical composition of seven samples of this limestone is given below :—

Insolubles and SiO ₂	R ₂ O ₃	CaO	MgO	Loss on Ignition
9.16—37.05%	1.20—3.72%	30.53—45.95%	1.18—3.26%	27.22—38.96%

(b) *Dharamkot hill*.—The total length of the Dharamkot outcrops in the north face is 600 m., and the maximum width is about 210 m. The reserves of cement grade limestone have been estimated at 14 million tonnes. The range in chemical composition of 16 samples is given below :—

Insolubles	R ₂ O ₃	CaO	MgO	Loss on Ignition
13.11—18.40%	0.90—1.16%	41.18—44.57%	0.91—3.44%	34.88—37.80%

(2) (i) *Dark grey limestone*.—The length of the limestone horizon is 425 m. from the top of the Dharmkot hill to the Supainu village. The width of the outcrop is about 30 m. and the true thickness of the limestone bands is about 18 m. The reserves of cement-grade limestone have been estimated at 1,080,000 tonnes. The range in chemical composition of 33 partial analyses of this limestone from Dharmkot hill is given below :—

CaO	MgO	
25.95—45.90%	0.60—5.30%	(Excepting one sample analysing 8.07% MgO).

(ii) *Kathari Block (On the southern end of Dharmkot hill)*. The reserves of cement grade limestone have been estimated at 600,000 tonnes.

(iii) *Lindi Behi hill*.—Grey limestones form a narrow zone on the hill with an extension of 300 m. and an average thickness of 15 m. The reserves are estimated at 200,000 tonnes down to a depth of 15 m. The range in chemical composition of six samples is given below :—

CaO	MgO
41.08—49.29%	1.92—3.73%

Mahendragarh district

J. P. Srivastava (1951) examined the limestone quarries of Dhani Bathuntha (27°59' : 76°07') and Kali-ka-Nangal (27°55' : 76°07'). The limestone occurs buried under the alluvium and blown sand and belongs to the Kushalgarh series of the Delhi system. A more or less continuous band exists between the two places for a distance of about 11.5 km. with a width of about 1.5 km. He further records limestone outcrops near Bahamanwas (27°52' : 76°09') and Binhari (27°51' : 76°09').

Limestone is being quarried at Dhani Bathutha and Kali-ka-Nangal for the manufacture of lime. The reserves are estimated at 17.5 million tonnes.

The analyses of the sample from these localities are given below :—

	Dhani Bathutha	Kali-ka- Nangal	Kasawati near Bed anti
Lime%	48.18	54.03	50.90
Magnesia%	4.66	2.37	3.58
Alumina and Ferric Oxide%	1.89	Nil	1.30
Silica (insolubles)%	1.31	1.93	2.60
Carbon dioxide% (Ignition loss)	43.98	41.66	41.57

Marble.—Dark and white marble is found in association with magnetite (iron ore) at Kamania-Chhapra-Antiri-Biharipur ridge. In these marble the silica content is 14 per cent and magnesia content 4 per cent.

Calcite.—Thick calcite veins occur associated with Karla and Datla hills which are about 5 km. N.W. of Narnaul.

REFERENCES

- Dutt, G. N., 1963.—A note on the Limestone prospects of Tunapathar, Ambala district, Punjab. *Indian minerals*, Vol. 17, No. 1, pp. 32-38.
- KOHLI, G., 1950.—A Preliminary note on the limestone outcrop in the Dharmkot R.F.; Kangra district, Punjab.
- KRISHNAN, M. S., 1955.—General report for 1950. *Rec. Geol. Surv., Ind.* Vol. 84, Pt. 1, p. 95-97.
- , 1958.—General Report for 1953. *Rec. Geol. Surv. Ind.*, Vol. 87, Pt. 1, p. 70-72 and 76.
- NAUTIYAL, S. P., DHOUNDIAL, D. P., DASGUPTA, S. P., AND RAMACHANDRA, A. V., 1958.—Report on the Dharmkot limestone for Portland cement manufacture, Kangra district. G.S.I. (Unpublished).
- RAINA, B. N., 1950.—Report on the detailed sampling of the limestone deposits between Tundapathar and Sherla, Amabala district. G.S.I. (Unpublished).
- ROY, B. C., 1962.—General Report for 1956. *Rec. Geol. Surv. Ind.*, Vol. 91, Pt. 1, p. 81.
- , 1962.—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. 1, p. 42 & 45.
- , 1962 b.—General Report for 1958. *Rec. Geol. Surv. Ind.*, Vol. 93, Pt. 1, p. 44 and 46.
- , 1962 c.—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, Pt. 1, p. 76-77.
- , 1964.—General Report for 1960-61. *Rec. Geol. Surv. Ind.*, Vol. 95, Pt. 1.
- , —General Report for 1961-62. *Rec. Geol. Surv. Ind.*, Vol. 96, Pt. 1,

REFERENCES—*contd.*

- SAHNI, M. R. AND FYENGAH, B. R. C., 1949.—Report on the limestone deposits between Tundapathar and Sherla. G.S.I. (Unpublished).
- SEWASTAVA, J. P., 1951.—Report on the investigation of limestone and gypsum in Chakki area for lime manufacture in Gurdaspur. G.S.I. (Unpublished).
- , 1958.—Report on the investigation of limestone quarries in the N.E.S. Block Loharu, Hissar district, for the manufacture of cement. G.S.I. (Unpublished).
- , 1958 a.—A note on the collection of bulk samples of high grade limestone from Tundapathar—Sherla districts. G.S.I. (Unpublished).
- West, W. D., 1950.—General Report for 1949. *Rec. Geol. Ind.*, Vol. 83, Pt. 1, p. 146.

LOCALITY INDEX

Ambala district :—

	Latitude-Longitude
Malla	30°46' : 77°00'
Dabsu	30°38' : 77°09'
Junpur	30°45' : 77°01'
Kharag	30°44' : 77°05'
Ramsar	30°41' : 77°06'
Mandi	30°40' : 77°07'
Tundapathar	30°45' : 77°01'
Sherla	30°40'30" : 77°07'00"
Kharag	30°42'50" : 77°05' 00"
Mataur	30°44'00" : 77°1'10"
Dabsu	30°43'40" : 77°02'00"
Ghaggar	30°35' : 76°50'
Ambri	30°43'10" : 77°03'20"
Jhakroh	30°42'50" : 77°05'20"
Jabial	30°41'30" : 77°06'00"

Gurdaspur district :—

Pathankot	32°17' : 75°40'
Dalhousie	32°30' : 75°55'

Hissar district :—

Loharu	28°28' : 75°47'
Bairan	28°35' : 75°45'
Bardu Chena	28°35' : 75°45'
Bisalwas	28°25' : 75°50'
Gagarwas	28°25' : 75°50'
Dhani	28°30' : 76°15'
Dhola	27°45' : 75°35'

Hosiarpur district :—

Mohindpur	31°18' : 76°18'
Birampur	31°10' : 76°10'

LOCALITY INDEX—*contd.**Hosiarpur district—contd.*

Latitude-Longitude

Khera Kaimot 31°17' : 76°19'

Lehra 31°16' : 76°10'

Kangra district :

Dharmsala 32°13' : 76°19'

Dundiara Rest House 32°30'30" : 75°55' 00"

Dharamkot 32°15'00" : 76°19'30"

Sheobagh 32°00' : 77°08'

Nagni 32°18' : 75°17'

Nurpur 32°18' : 75°55'

Samlarah 31°41' : 76°19'

McLeodganj 32°14' : 76°20'

Bal. 31°20' : 76°25'

Bhated Khad 32°15' : 76°15'

Mahendargarh district :—

Dhani Bathuntha 27°59'30" : 76°07'00"

Kahi-ka-Nangal 27°55' : 76°07'

Bahmanwas 27°52'30" : 76°9'30"

Binhari 27°51' : 76°09'

Narnaul 27°45' : 76°05'

Kamania. 27°55' : 76°05'

Chhapra 27°25' : 75°55'

Antri 27°55' : 76°58'

Biharipur 27°50' : 75°50'

RAJASTHAN

Ajmer district

Limestone deposits occurring in the following places of Ajmer district were examined by B. C. Roy in 1946-47.

1. *Ganguana* ($26^{\circ}32' : 74^{\circ}44'$).—An outcrop of fine-grained slightly siliceous limestone is exposed for about 400 m. with a N.E.—S.W. strike and width varying from 90 to 180 m. Over 1.52 million tonnes of limestone should be available down to a depth of 15 m. A sample of limestone was analysed as follows:— SiO_2 —24.46%, R_2O_3 —6.66%, MgO —8.89%, CaO —28.90%.

2. *Akhri*.—About 1.5 km. east of the Akhri Railway Station, a 200 m. wide dolomitic marble band occurs for 600 m. with a N.E.—S.W. to N.N.E.—S.S.W. strike and a steep westerly dip. The reserves are estimated at four million tonnes down to a depth of 15 m. The chemical analysis of a core sample of limestone is as follows:— SiO_2 —0.04%, R_2O_3 —1.36%, MgO —20.80%, CaO —30.77%, Loss on ignition—46.85%.

3. *Makhupura* ($26^{\circ}24' : 74^{\circ}40'$).—To the south-east of the locality, four bands of impure marble trend for 3 km. with interruptions in a N.E.—S.W. direction. The beds dip steeply towards north-west, and the total width ranges from 1.5 to 6 metres. The reserves are estimated at 350,000 tonnes of limestone in the vicinity of Makhupura down to a depth of 15 m. The analysis of a sample of limestone from this place is as follows:—

$\text{SiO}_2\%$	$\text{Al}_2\text{O}_3\%$	$\text{Fe}_2\text{O}_3\%$	$\text{MgO}\%$	$\text{CaO}\%$	Loss on ignition%
3.01	0.50	0.62	1.01	51.25	39.40

4. *Sulia Dungar* ($26^{\circ}24' : 72^{\circ}42'$).—Discontinuous marble and calc-silicate bands, 15 metres wide, extend for a few kilometres in a N.N.E.—S.S.W. direction with a vertical or steep dip towards the west. Around Sulia Dungar, the reserves of limestone have been estimated at 1.52 million tonnes down to a depth of 15 m. in a 3 km. long and 15 m. wide strip. The cement grade limestone may not exceed 10% of the total amount. The chemical analysis of a sample of limestone from this locality is as follows:—

$\text{SiO}_2\%$	$\text{Al}_2\text{O}_3\%$	$\text{Fe}_2\text{O}_3\%$	$\text{MgO}\%$	$\text{CaO}\%$	Loss on ignition%
4.16	3.42	1.08	1.02	50.12	40.15

5. *Hatondi* ($26^{\circ}17' : 74^{\circ}39'$).—Banded white dolomitic marble varying in width from a few metres to 15 m. extend with interruptions for 6.4 km. in a N.N.E.—S.S.W. direction with a vertical or steep easterly dip. The reserves have been estimated at 3.55 million tonnes assuming a total length

of 6.4 km. and an aggregate width of 15 m. One analysis of a sample of lime stone from this locality is as follows :

SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MgO%	CaO%	Loss on ignition%
0.56	0.51	0.69	20.37	30.97	46.64

6. *Kesarpura* (26°19' : 74°33').—Dolomitic marble striking E.N.E.—W.S.W. and dipping vertically or steeply northwards occur between Kesarpura and Saradhana (26°27' : 74°35'). The minor bands are only a few metres wide while others vary in width from 15 to 60 m. The reserves have been estimated at 25 million tonnes assuming a length of 4 km. and width of 200 m. One analysis of a sample of marble from this band is as follows :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Loss on ignition
0.44%	0.42%	0.88%	20.36%	31.28%	46.51%

7. *Sawar* (25°45' : 75°13').—Large deposits of siliceous limestone and some dolomite occupy an area of about 25 sq. km.

8. *Kotra* (26°01' : 74°13').—Impure marble, mostly calc-silicate rocks along with intercalations of gneisses and schists, commonly occurs in a N.N.E.-S.S.W. belt of the region, 6.4 km. long and 800 m. wide. The width of the individual bands varies from 1—60 m, the aggregate width being 15 m.

9. *Kharwa*.—Good quality marble occurs at Odas (26°18' : 74°19') and Sheopura (26°16' : 74°21'), 21 and 16 km. respectively, to the north-west of Kharwa R.S. About 3 miles (5 km.) S.E. of Kharwa in the hilly regions, calciphyre and marble bands occur in association with calc-granulites and gneisses trending N.E.—S.W.

10. *Sheopura* (26°01'00" : 74°22'30").—*Lulwa* (26°04' : 74°24').—K. K Mukherjee and S. C. Kapoor investigated these limestone deposits during 1959-60.

Sheopura is 11.3 km. south-east of Beawar. From Sheopura, the limestone bands of Delhi age extend in N.N.E. direction over a distance of 16 km. upto Kesarpura. These bands occur as narrow low ridges 60 to 90 m. high from the ground level. The width of the area is 3 km. Between Sheopura and Lulwa, the limestone bands occur as two parallel bands separated by 122 to 487 m. wide calc schist bands. The width of the eastern band varies from 548 to 609 m. The western band is 914 metres wide near Sheopura but narrows down to 274 m. near Lulwa. The dip in both the bands is about 70° towards W.N.W. and at places vertical. The limestone bands occurring over a distance of 6.5 km. between Sheopura and Lulwa have been sampled and analysed. 102 samples are analysed. Out of them 91 samples show variation of CaO from 42 to 50.8 per cent and MgO from nil to 2.3%. These analyses indicate the suitability of this limestone for cement manufacture. The probable reserves of cement grade limestone within this area are 424 million tonnes upto the ground level (average 50 m. from ridge tops). A further reserve of 254 million tonnes estimated for an additional depth of 30 m. (below ground level).

B. N. Sinha (1947-48) records a narrow, impure limestone band near Gudha ($26^{\circ}29'15'' : 74^{\circ}46'00''$) and another band 40 m. wide, about 2 kms. west of Maila ($26^{\circ}9'15'' : 74^{\circ}34'00''$).

Kedar Narain (1951-52) reports that limestone is burnt near Borwa ($26^{\circ}00' : 74^{\circ}21'$), Junpura ($25^{\circ}57' : 74^{\circ}19'$), and Baria Hira ($25^{\circ}56' : 74^{\circ}19'$) and is used locally for white-washing.

Marble in association with calc-silicate rocks and hornblende-schist was noticed by T. K. Kurien (1951-52) at Daulatpura ($26^{\circ}19' : 74^{\circ}17'$), Bakhtawarpura ($26^{\circ}19' : 74^{\circ}21'$), Kalesara ($26^{\circ}21' : 74^{\circ}25'$), Lakasam ($26^{\circ}19' : 74^{\circ}17'$) and within 6.4—19.3 km. from Mangaliawas R. S. The bands are 0.4 to 1.6 km. long, and 3 to 4.6 m. wide. Kurien (1952-53) also reports bands of white marble at Gadi Arjunpura ($26^{\circ}17' : 74^{\circ}32'$), Hatondi ($26^{\circ}21' : 74^{\circ}39'$), Miapur ($26^{\circ}20' : 74^{\circ}35'$), and Kesarpura ($26^{\circ}19' : 74^{\circ}33'$). The rock is not suited for use as an ornamental stone and hence can be used for lime burning: A grey cherty limestone at Tabiji ($26^{\circ}21' : 74^{\circ}36'$) is burnt for making lime. Thin bands of white marble are seen intercalated with quartzites at Makhupura ($26^{\circ}24' : 74^{\circ}40'$) and Narchi ($26^{\circ}29' : 74^{\circ}44'$).

C. Karunakaran (1951) reports the occurrence of marble in the prominent ridge 800m east of Ramgarh ($26^{\circ}4' : 74^{\circ}13'$). It occurs in thick regular bands with widely spaced joints over a strip 800-m long and 61 m. wide.

According to C. Karunakaran (1952) limestone and marble deposits suitable for lime burning, are found at Ajitgarh ($25^{\circ}47' : 74^{\circ}9'$) and Sonarkuri ($25^{\circ}42' : 74^{\circ}2'$), occurring as long ridges. C. Karunakaran (1955) reports that nodular limestone occurring on the surface near Kishengarh is extensively used for lime burning.

K. K. Basu (1960-61) records an occurrence of transparent to translucent variety of calcite near Tilonia R. S. ($26^{\circ}39' : 74^{\circ}57'$). A large part of the calcite vein is, however, covered by soil.

Alwar district

According to Fox (1945), there is a variety of tufaceous limestone near Ghatra, 548.0 m. long and 91.5 m. wide, not more than 2.7 m. thick, in the form of a cover over the quartzite hill to the west. The reserves are of the order of 254,000 tonnes.

An analysis of the tufa is given below :—

Insoluble silica		0.48%
Alumina and Iron Oxide		0.12%
Lime		56.23%
Magnesia		0.8 %
Loss on ignition		42.3 %
Alkalies		0.07%

Adyalkar (1957) states that marble is found in the area surrounding the Pratapgarrh copper belt. The marble is a medium to fine-grained, pure white, saccharoidal crystalline and belong to the Alwar series of the Delhi

System. It is said to be inferior to Makrana marble, as it is not quite suitable for fine carvings. It is locally used for statuary purposes.

Banswara district

P. N. Mukherjee (1945-46) reports a deposit of limestone and marble seen continuously between Khamera ($23^{\circ}47' : 74^{\circ}30'$) and Bhongra ($23^{\circ}41' : 74^{\circ}33'$) in an area of 10.3 sq. km. It is associated with amphibolites and calc-gneisses. An average sample on analysis indicate a high CaO content (51.64%) and the combined MgO and alkali below 3%, proving its suitability for the manufacture of cement. The reserve is estimated at 50.8 million tonnes within a depth of 4.6 m.

K. K. Mukherjee (1960-61) records the occurrence of limestone of fairly good quality near Pandwal ($23^{\circ}11' : 74^{\circ}16'$). The deposit is 1.5 to 3 m. thick covering an area of about 0.2 sq. km. It is locally used for lime burning.

Bikaner district

According to Crookshank (1948), the Vindhyan limestones in Bikaner reported to be present in large quantities, should be properly investigated to see whether adequate amounts of high grade materials would be available.

According to B. C. Roy (1954), an examination of shaft sections and bore-hole records at Palana shows that generally two to three bands of Nummulitic limestone, 0.45 to 0.6 m. thick, occur as intercalatory bands between the surface and the lignite seam. A sample of limestone analysed in the Geological Survey of India Laboratory gave the following results:

SiO ₂	R ₂ O ₃	CaO	MgO	Loss on Ignition
6.4%	3.9%	42.16%	5.36%	41.33%

Judging from the shaft sections and bore-hole records, B. C. Roy envisages extensive deposits of *kankar* suitable for lime-burning, throughout the Palana lignite field, below 1.5 to 3 m. of sand, the thickness of the *kankar* varying from 3 to 7.6 m.

Bhilwara district

V. R. Venkoda Rao (1958) recorded thin bands of medium to coarse-grained limestone belonging to the Ajabgarh series near Fatepura ($25^{\circ}47' : 74^{\circ}25'$), Lamba ($25^{\circ}53' : 74^{\circ}36'$) and Atalpara ($25^{\circ}50' : 74^{\circ}34'$). It is used locally for lime burning.

Bundi district

B. C. Roy (1954) examined the limestone deposits at Lakheri ($25^{\circ}40' : 76^{\circ}11'$). The quarry in the flat ground, referred to by Heron, is no longer worked for cement by the Associated Cement Companies. In recent years prospecting in the foothills of the main N. E.-S. W. trending ridge has proved the existence of extensive deposits of limestone suitable for cement.

The sequence of the formation, in descending order, is as follows :—

Upper Series (100'—110') (30.5—33.5m)	Upper dark grey, flaggy limestone (45% CaO). Lower ash coloured flaggy limestone (42.44% CaO)	Generally dipping 10°—15°
Middle Series (200'—220') (61—67m)	Low grade limestone bands with intercalatory shales. Good quality limestone with intercalatory shales. Mostly red argillaceous beds with minor limestone partings.	Generally showing steep inclinations.
Lower Series (40'—50') (12.2—15.2m)	Violet and pink flaggy limestone. Light coloured bedded limestone. (46% CaO)	Generally dipping 15°—20° and also steeply.
Red floor Series	Red calcareous shale with intercalatory limestone Dolomitic bands Green shales forming the plains	

Proceeding from S. W. to N. E. the important quarries in the Lower series at the foothills are 122 m., 61 m., 30.5 m., 244 m., and 1200 m. long respectively, with some 10.6-12.2 m. depth of cutting. No quarrying has commenced in the Middle series. In the Upper series there are also several quarries, the largest ones being 91.4 m. and 305 m. long with some 18.3 m. depth. Three samples analysed in the Geological Survey of India Laboratory gave the following results :—

	Dark grey Limestone	Pink Limestone	Violet Limestone
SiO ₂ %	15.96	8.52	17.73
R ₂ O ₃ %	3.50	2.70	3.30
CaO%	42.89	48.44	42.55
MgO%	1.56	0.43	0.58
Loss on ignition%	35.28	39.05	34.27

Chittorgarh district

According to M. L. Sethi (1958) the Chittorgarh limestone belongs to the Nimbahera stage. On the north it extends upto Baldrakha village, 10 km. north of the Bhenra village and towards the south it continues upto Kesarpura in Madhya Pradesh. Nimbahera limestone lies conformably on the Nimbahera shale with an average thickness of 122 m. to 152 m. in the locality. Limestone is pale brown or green in colour with occasional shales of brown or chocolate colour. It is fine grained and crystalline in texture. Limestone at this place has been quarried for the last century for production of slabs and tiles. The quarries are located close to the villages Bhanra,

Senthi, Segwa, etc. It is a fairly high grade limestone and its CaO content varies between 42% and 47% with a lower MgO content. Thus it is quite suitable for cement manufacture. The reserves are estimated at 335 million tonnes.

A detailed investigation for limestone deposit was carried out in Chittorgarh area. The sites selected for ten boreholes are :

1. Manpura 2. Bhoi Kheda 3. Kir Kheda 4. Near Chittorgarh Fort
5. Bhilong Ka Kheda 6. Chamthea Ka Kheda I 7. Chamthea Ka Kheda II 8. Sewgwa I 9. Segwa II and 10. Senthi.

These bore-holes were drilled vertically to a depth of about 30 m. each. All these holes passed through the limestone formation. About 500 core samples were analysed in the mineral Laboratory of the Directorate of Mines and Geology, Rajasthan and check analysis of about 100 were done from independent firms of analyst. The lime content generally varies from 42.25 to 47.6% and the MgO content is fairly low.

Dungarpur district

There are several NW-SE trending limestone bands about 1 km. east of Munger (28°52' : 74°12') in Dungarpur, the western bands being exposed at Nandli Anjni (23°55' : 74°11') and Dad (23°58' : 74°10') over a stretch of 13 km. There are other occurrences south-east of Nandli Anjni on the eastern slope of 1,033 point (23°55' : 74°12'), south-west of Jashpur Jabha (23°52' : 74°03') and near Hathai (23°54' : 73°56').

Fox (1947) noted a small deposit of *kankar* in the Padlara valley. A nodular limestone, resembling the Lameta limestone, is reported from near Chitrawal Magri.

Jaipur district

According to M. L. Sethi (1958) there are good limestone deposits about 18 km. east of Dabla. The quality and quantity have not been ascertained so far and limestone is chiefly used for lime burning.

Sethi (1958) also recorded a very high grade limestone in and around Kotputli. These deposits are located within a radius of 10 km. from Gordhanpura which is connected to Jaipur by 100 km. long metalled road. This limestone belongs to Ajahgarh series and is crystalline, fine to coarse grained in texture and is blackish grey to white in colour. A sample from this area gave the following results SiO₂—6.7%, R₂O₃—1.2%, CaO—49.64% MgO—1.06%, Loss on ignition—1.48%.

The reserves from Kotputli area are estimated at 539 million tonnes.

Jhunjhunu district

According to M. L. Sethi (1958) limestone occurs as bands of variable thickness near Kala Khokhra about 11 km. west of Maonda railway station on Phulera-Rewari chord line of Western Railway. The rock is crystalline and grey in colour. It contains on an average 46.45% CaO and 1.9% of MgO. At some places the MgO content is somewhat higher. The reserves are estimated at 100 million tonnes.

Twenty-one bore-holes have been drilled at various places in this area. In three bore-holes the drilling was continued upto 61 m. to determine the depth persistence of the limestone. It was found that limestone continued beyond this depth. In the limestone core samples received from the bore-holes drilled at Sahajanwali, Shikarwali, Kala Khokhra, etc., the lime content was as high as 46% and MgO less than 2%. Samples from a few boreholes indicated sometimes a higher percentage of MgO.

Jodhpur district

B. C. Roy (1954) investigated the limestone deposit at Gotan ($26^{\circ}39' : 73^{\circ}45'$). The area is worked by Messrs. Gotan Lime Syndicate for high quality lime for use in railway projects, textile mills, sugar mills, tanneries, chemical works, explosive factory, etc. Limestone occurs in a flat terrain and is in the form of almost horizontal or gently tilted beds dipping at places 5-10 degrees east or west, with a maximum overburden of 1.5—2.4 m., composed of soil, kankar and impure altered flaggy limestone. Judging from the numerous shallow pits, 1.5—6.1 m. deep, there is a 1.5—1.8 m. thick bed of fine to coarse bedded and jointed, high grade, dark grey to light grey limestone, underneath the overburden which is being worked at present. A light grey or cream coloured, spongy, low-grade limestone, 2.4—3 m. thick, underlies the good quality limestone bed. In a 1.6 km. long and 1.6 km. wide strip, south of the railway line about 8 million tonnes of high grade limestone may be present, assuming about 5% of the deposit as being worked out. The deposit, however, is actually much more extensive. Two samples analysed in the Geological Survey Laboratory gave the following results :—

SiO ₂ %	R ₂ O ₃ %	CaO%	MgO%	Loss on Ignition%
0.56	0.80	53.99	0.41	43.09
0.70	0.50	54.25	0.57	43.10

Kotah district

Crookshank (1946) reports that good travertine deposits, used for lime burning are noticed along the road near Kasar in Kotah.

G. G. K. Sastry (1950) investigated the limestones of the Nimbahera and Lower Bhandar stages of the Vindhya in this district.

The limestone bands between Julmi ($24^{\circ}35'10'' : 75^{\circ}59'15''$) and Mailo ($24^{\circ}39'25'' : 75^{\circ}58'00''$) and between Nimana ($24^{\circ}41'30'' : 75^{\circ}59'00''$) and Deoli ($24^{\circ}48'30'' : 75^{\circ}52'00''$) occur over an area of about 32 km. long and about 400 m. wide. The thickness is about 61 to 76 m. The CaO content of this limestone varies from 29.80% to 48.10% and the magnesia is generally very low, varying between trace and 1.10%. The limestone is highly siliceous, the minimum silica percentage being as high as 12.37%. Hence this limestone is suitable for the manufacture of cement. The massive Lower Bhandar limestone, exposed generally as a continuous scarp in the Mukandwara hill range for a distance of about 55 km. is 6.1—13.7 m. thick and dips very gently to the north-east. The CaO content of this limestone

ranges from 26.08% to 43.21% and the MgO from 1.30% to 20.58%. The silica and alumina percentages are usually low. This limestone is suited for lime burning.

According to M. L. Sethi (1958) Vindhyan limestone is quarried extensively near Ramganjmandi, Morak and Suket about 32 km. south of Kotah. It is fine-grained and takes polish with ease. Chemical composition of this limestone is as follows :—

SiO ₂ %	19.16	18.10	16.9
R ₂ O ₃ %	4.92	5.00	5.5
Fe ₂ O ₃ %	0.76	1.3	1.1
CaO%	41.04	41.16	42.6
MgO%	0.86	..	..

T. K. Kurien (1955) reports the occurrence of light grey limestone suitable for lime burning at Kolipura (24°58' : 74°40'). According to T. K. Kurien (1955), *kankar* is quarried for lime burning in the neighbourhood of Khera Jagpura (25°04' : 75°52').

Nagaur district

M. L. Sethi (1958) records the occurrence of Vindhyan limestone at Mundwa. It is exposed at Didia, Kherwar, Gagwana and Rol. The limestone is mainly used for lime burning and is of medium grade. The CaO content varies usually between 35 and 48% and the MgO content is slightly higher than in the deposits at Gotan and Sojat. The reserves are estimated at 100 million tonnes.

Pali district

According to M. L. Sethi (1958), the limestone at Sojat, Bilara and Atbara belongs to Vindhyan System. The outcrops are seen in the villages of Ramasui, Dhaneri, and Madla. The limestone beds continue towards the north with an average width of 5 km. for a distance of about 22 km. Towards the eastern side, this belt passes through Mandla, Rundia, Atbara, and Haras. There are about 50 quarries near this place. The overburden varies from 1.5 to 3 m. and the maximum depth attained in the quarries is 7.6m. The limestone is available in various shades of colour from cream to black, the usual colour being grey. It is massive and coarse grained. The reserves are of the order of 396 m. tonnes. Crookshank quotes the analysis by Messrs. R. V. Briggs & Co. of a sample from Sojat area as follows :—

CaCO ₃	MgCO ₃	CaSO ₄	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	Alkalies
95.6 %	0.96%	0.15%	2.88%	0.14%	0.10%	0.17%

S. Das Gupta (1960) records the occurrence of a fairly persistent, 3 to 6 m. wide band of calcite in impure marble over a length of 150 m. near

Kararewao ($24^{\circ}53' : 73^{\circ}10'$). It is, however, intimately associated with quartz veins. Minor bands of calcite occur to the east of Baneri ($24^{\circ}52' : 73^{\circ}10'$), south of Bhimana ($24^{\circ}50' : 73^{\circ}13'$), Bhanpura ($25^{\circ}03' : 73^{\circ}28'$), and Piplan ($25^{\circ}04' : 73^{\circ}21'$). The deposit at five kilometres north of Bhanpura measures 90 m. by 9 m. and is likely to yield good quantities of semi-transparent to transparent crystals of calcite.

Sawai-Madhopur district

According to Crookshank (1946), the ridge between Niladonga (Kaildevi) and Maloli contains adequate quantities of material suitable for cement. This locality would probably be the nearest source of large quantity of cement grade limestone from Delhi and Agra. The Railway Station of Gangapur city is about 16 km. away from the deposit. The limestone at Niladonga appears to be of a better quality massive variety, while the one near Maloli is flaggy.

Limestone is available at Naraoli (Anjakapura) and Jhirota to the west of Karauli state. At the former locality, the deposit is about 8 m. thick horizontally bedded, and covers an area of 0.8—1.2 hectares. The quality at the surface is very siliceous. The deposit is 1.6 km. south of Naraoli and occurs as gently dipping beds over an area 0.8 km. long and 0.4 km. wide. The material is fairly uniform and appears to be of good quality. The deposit is within 3.2 km. of Narainpur Tatwara R.S.

According to M. L. Sethi (1958), a limestone deposit is situated near the village of Phalodi about 32 km. S.S.E. of Sawai-Madhopur and 8 km. from Rawanjana Dungar R.S. The workable bands occur in a few horizontal beds each with a thickness of 1.5—2.1 m. at the foot of the hill. The deposits are quite extensive. The analysis of a sample is as follows :— SiO_2 —2.13%, CaO —42.32%, MgO —1.77%, R_2O_3 —3.00%, Loss on ignition—37.5%.

Sethi also reports a deposit of limestone which forms a hill feature locally termed as Lila Dungri between Maholi and Kelan Devi villages. The deposit is situated about 32 km. south-west of Karauli. The limestone is of fairly high grade and contains about 46% of CaO and about 0.9% of MgO . The reserves are estimated at 100 million tonnes.

Sikar district

According to M. L. Sethi (1958) good quality calcite and limestone deposits occur near the Raipur village, about 23 km. east of Nim-Ka-Thana.

Sirohi district

B. C. Roy (1953) investigated the limestone deposits occurring at the following places :

- (1) Abu Road ($24^{\circ}28'30'' : 72^{\circ}47'$) ; (2) Dhanwau ($24^{\circ}31'00'' : 72^{\circ}47'30''$)
- (3) Akhra ($24^{\circ}30'30'' : 72^{\circ}50'00''$) ; (4) Pandore ($24^{\circ}32' : 72^{\circ}52'$)
- (5) Murthala ($24^{\circ}31' : 72^{\circ}49'$) ; (6) Kivarli ($24^{\circ}32' : 72^{\circ}50'$)
- (7) Mawal ($24^{\circ}26'00'' : 72^{\circ}45'30''$) ; (8) Amba Mata ($24^{\circ}20'00'' : 72^{\circ}51'30''$)

Pandore.—The limestone strip to the south-west of Pandore is over 1.5 km. long and 0.2 km. wide. It is mostly inferior and is partly crystalline dipping 50° to 70° to the southeast. A sample analysed gives the following results :

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
9.50%	4.04%	2.80%	46.73%	37.53%

In an area 800 m. long and 65 m. wide, nearly 726,000 tonnes of the material would be available.

Akhra.—On both sides of the Mount Abu Road, grey limestones with a strike NE-SW occur. In the western area about two million tonnes of limestone would be present within a depth of 8 metres over 13 hectares. The eastern strip probably contains about 1.5 million tonnes of limestone within of a depth of 8 m. over an areas 20 hectares.

A sample from west of Mount Abu road analyses as follows :—

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
3.38%	0.96%	3.72%	49.52%	42.14%

Murthala.—South-west of Murthala between the rivers Banas and the railway line in a strip 1.5 km. long and 800 m. wide possibly a reserve of 11.6 million tonnes of limestone would be available within a depth of 8 m. About 20% of the deposits have been worked out leaving a probable reserve of nearly 9.2 million tonnes. The limestone band has a strike between east-west and E.N.E.-W.S.W., dipping vertically or 75° to 80° southwards. The limestone is light to dark grey in colour and is usually massive in appearance. Two analyses are given below :—

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
%	%	%	%	%
3.50	2.84	2.03	49.53	50.86
0.91	2.58	3.15	50.86	43.00

Kivanli.—The limestone strip north-east of Kivanli, between the railway line and the Banas river occurs along a stretch of 1.5 km. The limestone bands have a strike commonly between N.E.-S.W. and E.N.E.-W.S.W., dipping usually vertically or at high angles towards S.E. or S.S.E. The limestone is light to dark grey, massive or flaggy. Here altogether 0.3 million tonnes of material may be available.

Two samples analyse as follows :—

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
%	%	%	%	%
3.64	1.75	2.04	50.17	41.46
5.29	1.99	2.57	49.40	40.71

Abu Road.—Extensive deposits of limestone are found in the hilly region about 1.5 km. east of the Abu Road railway station. The bands have a strike between NE-SW and N.N.E-S.S.W. and dip almost vertically. In a N.N.E-S.S.W. ridge 400 m. in length, 20 to 75 m. in width and 22 m. in height roughly 0.7 million tonnes of material would be available.

A sample analyses as follows:

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
7.33%	3.84%	2.23%	50.34%	36.51%

Mawal.—About 2.4 km. off Mawal Railway station, large deposits of impure limestones are present. An analysis is given below:

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
19.85%	9.48%	..	40.03%	27.71%

Amba Mata.—Extensive deposits of calciphyre, calc-silicate rocks, marble, etc., are present near Jariba, Kotisar, Chikla, and Kumbaria, etc.

Dhanwau.—In a strip 300 m. long and 180 m. wide, about 600,000 tonnes of limestone would be available within a depth of 5 m. An analysis of a sample is given below:—

SiO ₂	R ₂ O ₃	MgO	CaO	Loss on ignition
6.10%	..	..	49.94%	39.24%

Tonk district

According to Crookshank (1946) limestones from Binota in the Nimbahera area contains 1.64% of MgO and 71% of CaCO₃. He suggested detailed prospecting to find out the potentialities for cement manufacture. The limestone deposit at Amli is of minor importance and is suitable for local limeburning.

Udaipur district

According to C. Karunakaran (1949) symmetrically folded beds of limestones with dips varying from 25° to 45° are abundant in the area around Chitorgarh. Underneath the shale the bands extend upto Chanderia (25°57' : 74°40') and they do not crop out in the tract north of Chanderia. Southwards the limestone outcrops are almost continuous till Bhojunda, about 3.2 km. south-west of the Chitorgarh railway station. Further west, the limestone outcrops disappear. Eastwards, limestones with a regular westward dip of 40°—55° appear in a tract about 1.6 km. wide upto the foot of the Chitor Fort ridge. North-east of the Chitorgarh railway station, limestone dips at 30° to 40° in a south-easterly direction. A limestone band is also reported from the tract between Bagan and Gameri rivers. The variation in chemical composition of 17 chip samples of limestone from this area is as follows:

SiO ₂ and Insol.	R ₂ O ₃	MgO	CaO	Loss on ignition
8.02—28.28% 3 GSI/64	1.60—3.45%	Trace—1.02%	37.91—49.52%	30.98—39.70%
				15

The CaCO_3 content varies from 68.70 to 88.49% and MgCO_3 from trace to 2.14%.

The limestone outcrops occur in an area of 18 sq. km. The reserves of limestone have been estimated at 287 million tonnes down to a depth of 6 m.

According to M. R. Subramanyam (1951) the marble deposits extending from Chaterji Ka Gudha ($25^\circ 16' : 73^\circ 54'$) to Lawe Sardagarh ($25^\circ 14' : 73^\circ 59'$) in the Udaipur district have been extensively used for building purposes.

REFERENCES

- CROOKSHANK, H., 1946.—Preliminary Report on the minerals of economic value in Karali State (Unpublished).
 ———, 1946.—Minerals of Tonk State (Unpublished).
 ———, 1946.—Geological Report on Kotah State (Unpublished).
 ———, 1948.—Note on mineral wealth of Bikaner (Unpublished).
 ———, 1948.—Suggestions for the development of the mineral wealth of Marwar (Unpublished).
 FOX, C. S., 1945.—The mineral resources of Alwar State, Rajputana, p. 12-14, 23-24, 27-28.
 ———, 1947.—The mineral resources of Dungarpur, Rajputana, p. 13-14.
 KARUNAKARAN, C., 1951-52.—Progress Report for 1951-52 (Unpublished).
 ———, 1950.—Investigation of Limestones near Chitorgarh, Udaipur State, Rajasthan (Unpublished).
 KEDAR NARAIN, 1951-52.—Progress Report for 1951-52. (Unpublished).
 KRISHNAN, M. S., 1953.—General Report for 1950. *Geol. Surv. Ind.* Vol. 84, Pt. I, p. 82-83, 897.
 ———, 1954.—General Report for 1951. *Rec. Geol. Surv. Ind.* Vol. 85, Pt. I, p. 53.
 ———, 1954.—General Report for 1952. *Rec. Geol. Surv. Ind.* Vol. 86, Pt. I, p. 106-107.
 ———, 1958.—General Report for 1953. *Rec. Geol. Surv. Ind.* Vol. 87, Pt. I, p. 106-109.
 ———, 1958.—General Report for 1954. *Rec. Geol. Surv. Ind.* Vol. 88, Pt. I, p. 81, 122-124.
 KURIEN, T. K., 1951-52.—Progress Report for 1951-52. (Unpublished).
 ———, 1952-53.—Progress Report for 1952-53. (Unpublished).
 ROY, B. C., 1947.—Report on the Mineral Survey in Ajmer—Marwara (Unpublished).
 ———, 1953.—The Limestone deposits in Ajmer State (Unpublished).
 ———, 1954.—The Report on certain economic minerals and rocks in Rajasthan (Unpublished).
 ———, 1959.—The Economic Geology and Mineral Resources of Rajasthan and Ajmer. *Mem. Geol. Surv. Ind.* Vol. 86, p. 208-223.
 SETHI, M. L., 1958.—Proceedings of the Symposium on manufacture and use of building lime in India. p. 26-34, National Buildings Organisation's publication.
 SINHA, B. N., 1947-48.—Progress Report for 1947-48. (Unpublished).
 WEST, W. D., 1951.—General Report for 1949. *Rec. Geol. Surv. Ind.* Vol. 83, Pt. I, p. 148.

LOCALITY INDEX

Ajmer district :

Latitude : Longitude

Gangwana	26°32' : 74°44'
Makhupura	26°24' : 74°40'
Sulia Dungar	26°24' : 72°42'
Saradhaua	26°27' : 74°35'
Sawar	25°45' : 75°13'
Khorwa	26°18' : 74°19'
Sheopura	26°01'00" : 74°22'30"
Lulwa	26°04' : 74°24'
Gudha	26°29'15" : 74°46'00"
Maila	26°9'15" : 74°34'00"
Borwa	26°0' : 74°21'
Junpura	25°57' : 74°19'
Baria Hira	25°56' : 74°19'
Baulatpura	26°19' : 74°17'
Bakhtawarpur	26°19' : 74°21'
Kalesara	26°21' : 74°25'
Lakasam	26°19' : 74°17'
Arjunpura	26°17' : 74°32'
Hatondi	26°21' : 74°39'
Maipur	26°19' : 74°21'
Kesarpura	26°19' : 74°33'
Tabiji	26°21' : 74°36'
Makhupura	26°24' : 74°40'
Naretoli	26°29' : 74°44'
Ramgarh	26°04' : 74°13'
Ajitgarh	25°47' : 74°39'
Sonarkuri	25°42' : 74°02'
Tilonia	26°39' : 74°57'

LOCALITY INDEX

*Alwar district :**'Latitude : Longitude*

Ghatra	25°10' : 80°10'
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Banswara district :

Khamera	23°47' : 74°30'
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Bhongra	23°41' : 74°33'
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Pandwal	23°11' : 74°16'
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Bikaner district :

Palana	24°45' : 73°50'
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Dholwara district :

Fateपुरa	25°47' : 74°25'
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Lamba	25°53' : 74°36'
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Atalपुरa	25°50' : 74°34'
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Bundi district :

Lakhiri	25°40' : 76°11'
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Dungarpur district :

Munger	28°52' : 74°12'
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Anjri	23°55' : 74°11'
-----------------	-----------------

Dad	23°58' : 74°10'
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Nandli Anjri	23°55' : 74°12'
------------------------	-----------------

Tashpur Jabha	23°52' : 74°03'
-------------------------	-----------------

Hathai	23°54' : 77°56'
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Kotah district :

Julmi	24°35'10" : 75°59'15"
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Mailo	24°39'25" : 75°58'00"
-----------------	-----------------------

Nimsua	24°41'30" : 75°89'00"
------------------	-----------------------

Deoli	24°48'30" : 75°52'00"
-----------------	-----------------------

Ramganjmandi	24°35' : 75°55'
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Khera Jagpura	25°4' : 75°52'
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LOCALITY INDEX

Nagaur district :

Latitude : Longitude

Gotan 26°35' : 72°40'

Sojat 25°55' : 73°40'

Pali district :

Bilara 23°55' : 74°50'

Atbara 26°00' : 73°40'

Kararewad 24°53' : 73°10'

Baneri 24°52' : 73°10'

Bhimana 24°50' : 73°13'

Bhanpura 25°03' : 73°28'

Piplan 25°04' : 73°21'

Sawai-Madhupur district :

Naraoli 26°15' : 76°45'

Jhirota 26°15' : 75°00'

Sikar district :

Raipur 27°40' : 75°55'

Sirohi district :

Abu Road 24°28'30" : 72°47'00"

Akhra 24°30'30" : 73°50'00"

Murthala 24°31' : 72°49'

Mawal 24°28'00" : 73°45'30"

Bhauwan 24°31' : 72°52'

Pendore 24°32' : 72°52'

Kivarli 24°32' : 72°50'

Amba Mota 24°20'00" : 72°51'30"

Tonk district :

Bindta 24°30' : 74°30'

Amli 24°40' : 74°00'

LOCALITY INDEX

*Udaipur district :**Latitude : Longitude*

Chandaria 25°57' : 74°40'

Chaterji Ka Gudha 25°16' : 73°54'

Sardagarh 25°14' : 73°59'

UTTAR PRADESH

Almora district

Kedar Narain (Roy, 1962, p. 45) investigated the limestone occurrence associated with the Garhwal window Series, near Chaukhutia. Limestone occurs as a large belt 4 km. wide and stretches in a north-south direction over a distance of more than 64 km. from Dhanpur ($30^{\circ}13' : 79^{\circ}06'$) upto Dwarhat ($29^{\circ}47' : 79^{\circ}26'$). Although the bulk of the limestone is dolomitic, some bands are rich in calcium carbonate and can be utilized for manufacturing cement by selective mining. The reserves of the limestone in the area have not been estimated but are expected to be large.

Massive limestone occurs near Ganpurgarh ($30^{\circ}5' : 79^{\circ}20'$) and extends upto Manwa Devi ($29^{\circ}52' : 79^{\circ}25'$). Similar limestones are found along the Alakananda between mile stones 143 ($30^{\circ}25' : 79^{\circ}24'$) and 156 of the pilgrim track.

Extensive deposits of cement-grade crystalline limestone also occur inter-bedded with slates in the valley of Kosi.

Banda district

As reported by Prem Swarup and H. S. Ranhotra (1960) Lower Vindhyan Tirohan limestone is exposed in Kamath Nath Hills near Karwi in the Banda district. The exposed thickness of limestone band varies between 30 and 46 m. The limestone formation is well jointed and shows a gentle dip of 3° towards the south-east. The limestone from this area is reported to contain 18 per cent of magnesia.

Calc-tufa is also reported from the Chauri area ($24^{\circ}50'15'' : 80^{\circ}54'40''$) in the Karwi *tehsil* of this district. The occurrences are located in the Hindol, Tillia, Dalua, Amha and Pauna *nalas*.

Chamoli district

A. P. Tewari (Roy, 1964) recorded the occurrence of a thick bed of crystalline marble near Kindola Khal ($30^{\circ}38' : 78^{\circ}55'$) at an altitude of 3,300 m. A thin bed of marble also occurs in the Mandakini valley near Kund Chitti ($30^{\circ}30' : 79^{\circ}06'$).

Dehra Dun district

Dehra Dun-Mussoorie Area.—According to D. R. S. Mehta, B. R. Narayan Murthy and A. S. Narasimhan (1959) the limestones of this area belong to the Krol series. The Upper Krols are for the most part dolomitic, the limestone being confined mainly to the Krol C stage of Auden. The limestone deposit in this area extends from south-east of Sisoli ($30^{\circ}23' : 78^{\circ}8'$) and runs in a general north-west direction along Sahasradhara, Jud, Kerwan Oak Grove, Jharipani, Bhatta, Hathipaon up to *Cloud End* south of Mussoorie.

The limestone in the Sisoli area has a considerable thickness of a zone with CaO above 55%. The total thickness of the limestone is 252 m. of which only about 6% is the aggregate thickness of the included dolomitic zones. A continuous zone of limestone runs for about a distance of 15,240 m. between Sisoli and to the west of Bhitarli Nadi. The Sisoli-Sahasradhara area has the best limestone deposit from the point of view of reserves and quality.

The variation in the chemical composition of 36 samples of limestone from the Sisoli area is as follows:—

CaO	MgO
36.68—55.41%	Trace—12.56%

Near Sahasradhara the limestone formation decreases to about 240 m. in thickness and the dolomitic zones constitute only 25% of the total thickness. It runs north-west from Sahasradhara to Jharipani. The White micro-crystalline limestone makes its appearance near Jharipani and becomes thicker near Bhatta and further to the west. Some samples from the Bhatta quarries show CaO to be as high as 55.77%.

The estimated thickness of the main formation is about 200 m. near Jud and further north it is only 117 m. across the Richpana river near Arnighat. The total thickness of the included dolomitic zones varies from 35 to 50% of the total. The thickness near Jharipani is 143 m. and the included dolomitic zones form 60% of the total thickness.

The variation in chemical composition of 133 samples of limestone from the Sahasradhara area is as follows:—

CaO	MgO
15.39—55.16%	Trace—16.70%

Out of the 133 samples, 74 give CaO above 45% and MgO less than 5%.

West of Bhatta *Nala*, the outcrop continues to run uninterrupted across the Bhitarli Nadi in a general W.N.W. direction. This sector which is 5 km. long, has the thickest and longest zone of micro-crystalline limestone with CaO above 55%. The aggregate thickness of the main formation between Bhatta and Bhitarli *Nalas*, is 183 m., 72% of which are dolomitic. The estimated thickness near the western end is 172 m., of which 30% are dolomitic.

Two isolated lenticular bodies of limestone, 1,065 m. and 914 m. long respectively, occur to the west of the Bhitarli *Nadi*. Both follow the general strike trend in the area which is W.N.E.—E.S.E.

The thickness of the limestone zone at the hill 6748 is 200 m., 10% of which constitutes dolomitic zones. The northern limestone zone has an estimated thickness of 144 m. with included dolomitic zones forming 22% of the total thickness.

The variation in chemical composition of 13 samples from the limestone band exposed on the hill $\Delta 6748$ ($30^{\circ}27' : 78^{\circ}1'40''$) is as follows:—

SiO ₂	Insolubles	R ₂ O ₃	CaO	MgO
0.043—0.88%	0.087—0.53%	0.17—0.90%	42.01—55.16	0.41—6.13 (one sample analysed 11.75)

(Analyses by Harcourt Butler Technological Institute, Kanpur.)

The Hathipaon-Cloud End limestone zone runs for a distance of about 309 m. and has a 6 m. thick zone with CaO above 55% over a third of the total distance. The thickness of the limestone zone varies from 70 to 228 m. from east to west, with the combined thickness of the included dolomitic zones varying from 17 to 33%.

The variation in the chemical composition of the 14 samples from Hathipaon are (30°27' : 78°02') is as follows :

SiO ₂	Insolubles	R ₂ O ₃	CaO	MgO	CaCO ₃	MgCO ₃
0.10—0.62%	0.04—0.48%	0.20—2.16%	35.72— 55.10%	0.35— 17.79%	72.15— 98.40%	0.73— 34.38%

(Analyses by Harcourt Butler Technological Institute, Kanpur.)

The reserves have been calculated sector-wise as given below :—

Sector and quality of limestone	Length of outcrop in metres	Average thickness in metres	Quarriable reserves in tonnes upto 30 m. along dip (approx)
1	2	3	4
I. Sisoli to Bhatta—			
(a) CaO 42.19% MgO 6.19%	10,210	158	132,000,000
(b) CaO 50.55%	10,210	80	68,523,000
(c) CaO above 55%	2,163	15	2,744,000
II. Bhatta to South of Hill Δ 6748—			
(a) CaO 47.66% MgO 4.33%	4,572	146	54,887,000
(b) CaO 50—55%	4,572	60	22,728,000
(c) CaO above 55%	914	16	1,250,000
III. Hill Δ 6748—			
(a) CaO 50.96% MgO 2.73%	1,066	200	17,500,000
(b) CaO 50—55%	1,066	156	13,656,000
(c) CaO above 55%	1,066	22	2,000,000
IV. North of Hill Δ 6748—			
(a) CaO 51.48% MgO 2.65%	914	145	10,800,000
(b) CaO 50—55%	914	114	8,531,000
V. Hathipaon to Cloud End—			
(a) CaO 51.16% MgO 3.29%	3,300	145	40,000,000
(b) CaO 50—55%	3,300	108	30,000,000
(c) CaO above 55%	1,004	6	500,000

Consolidated table of reserves in tonnes down to 30 metres along dip

Average quality	<i>In situ</i> reserves	Quarriable reserves
A. CaO 45.77% MgO 4.95%	2,545,000,000	254,500,000
B. CaO 50.55%	1,428,000,000	142,790,000
CaO above 55%	65,000,000	6,500,000

Exposures of siliceous Mandhali limestone occur near Mandarsu about 10 km. from Kalsi. According to Krishna Mohan (1962), the deposit extends for about 3.5 km. with an average thickness of 137-152 m. The reserves are not estimated but are believed to be several million tonnes of cement grade limestone.

Deposits of Upper Krollimestone are also found near Barkot (30°17' : 78°15'), Bhainsudhar, Ghoran hill, Ghorapitti hill and Kutia Ridge. According to Krishna Mohan (1962), the average MgO was found to be 5% ; while CaO average 50% and silica, alumina, etc., are within permissible limits. The total reserves of cement-grade limestone excluding the dolomitic bands from the above deposits are estimated at 39 million tonnes.

According to Krishna Mohan and Ravi Prakash (1956) extensive deposits of limestone of Lower Palaeozoic age are exposed on Deoban Hill in the Chakrata *tahsil*, showing a northerly dip. The limestone is greyish white in colour and seems to be dolomitic in composition.

As reported by A. K. Zuberi (1956) limestone *in situ* and also in the form of big boulders occurs at Lorsi about 24 km. from Rishikesh.

Garhwal district

Deposits of Upper Tal limestone, low in magnesia occur near Nilkanth Pundras, Toli, Manikot, Hill 4582 and Bhadsi (30°06' : 78°21') in the Garhwal district. The limestone is sometimes traversed by pure calcite veins, and is often interbedded with thin bands of shales. According to Krishna Mohan (1962) low grade limestone sample from, Toli village give 35.4% CaO, 31.8% SiO₂, 1.1% MgO, 2.06% Fe₂O₃ and 1.10% Al₂O₃. The beneficiation tests show that quartz was the principal gangue in the sample and was liberated at 150 mesh. Mapping and detailed trenching between the Ganga, Huini and Bidasini rivers has revealed that several million tonnes of siliceous limestone with an average 33% of SiO₂ is available and over 31 million tonnes can be easily exploited.

Kedar Narain (Roy, 1961, p. 121) examined the massive limestone bands of the Garhwal series exposed between the village Tila (29°12' : 79°6') and Guar (30°14' : 79°07'). A number of samples analysed in the laboratories of the Geological Survey of India reveal that the rock is highly magnesian, the MgCO₃ contents ranging between 35.36% and 62.68% and CaCO₃ between 12.81% and 51.62%.

Mirzapur district

According to Muktinath (1951) there are four types of limestone found in the district :

- (1) Rohtas limestone of the Rohtas stage,
- (2) Kajrahat limestone of the Basal stage,
- (3) Fawn limestone of Kheinjua stage,
- (4) Crystalline limestone of pre-Vindhyan age near Belwadah in Southern Mirzapur.

The limestone belt of the Rohtas stage extends for a distance of 128 km. in the Mirzapur district, along the northern bank of the Son river. These are exposed in the southern escarpment of the Kaimur plateau from Silpi ($24^{\circ}37' : 82^{\circ}50'$) on the western border of the district to Basuhari ($24^{\circ}31' 30'' : 83^{\circ}30'00''$) on the eastern border. The thickness of the Rohtas stage varies from 120 to 210 m. The maximum thickness is near Markundi ($24^{\circ}36' : 83^{\circ}06'$). The limestone of the Rohtas stage are usually grey in colour and are interbedded with shales.

In the western part of the belt extending from Silpi ($24^{\circ}37' : 82^{\circ}50'$) to Gurdah ($24^{\circ}36' : 82^{\circ}59'$), the limestone is exposed at Silpi Kota ($24^{\circ}37' : 82^{\circ}51'$), Hirakhair ($24^{\circ}37' : 82^{\circ}55'$), Alaur ($24^{\circ}37' : 82^{\circ}57'$) and Gurdah in cliff sections, in the Son river and in between the river and cliff sections.

At the base of the Rohtas stage there is a bed of nodular limestone, south of Rijul ($24^{\circ}37' : 82^{\circ}50'$). The variation in the chemical composition of 15 samples of limestone analysed from the western part of the belt is as follows :

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
0.08—24.44%	0.04—2.72%	0.14—2.20%	34.34—47.21%	1.10—5.82%

The percentage of MgO in the limestone is usually too high for cement but thin bands of limestone of good quality occur at the base of the hill at Jamua ($24^{\circ}38' : 82^{\circ}51'$), Belwa ($24^{\circ}37' : 82^{\circ}54'$) and Silpi ($24^{\circ}37' : 82^{\circ}50'$). On an average about 30 m. of limestone in the upper part of the escarpment between Markundi ($24^{\circ}36' : 83^{\circ}06'$) and Kanach ($24^{\circ}29' : 83^{\circ}04'$), a distance of about 19 km. this is suitable for the manufacture of cement.

In the central part, limestone is exposed in (1) the cliff sections, (2) the Ghaghar river, and (3) the *nalas* between the Ghaghar and the cliff sections.

The limestone occurs throughout the escarpment overlooking Markundi ($24^{\circ}36' : 83^{\circ}06'$), Makribari ($24^{\circ}35' : 83^{\circ}08'$), Radauli ($24^{\circ}36' : 83^{\circ}08'$), Belach ($24^{\circ}33' : 83^{\circ}07'$), Pataudh ($24^{\circ}32' : 83^{\circ}05'$), etc. for a distance of about 19 to 20 km. The thickness of the limestone formation varies between 7 and 36 m. The general dip of the limestone formation is towards the north, varying between 10 and 12 degrees. The variation in chemical composition of 28 samples of limestone from this portion is as follows :—

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
3.12—16.30%	0.09—2.81%	0.74—2.10%	42.60—53.12%	0.08—5.15%

Out of these 28 samples, 18 analyse less than 10% SiO_2 and only one sample analyses more than 5% MgO .

Grey Rohtas limestone is also exposed in the Ghaghar river from 1.5 km. north of Markundi to Pataudh for a distance of about 7 km. The variation in chemical composition of 8 samples of limestone from this sector is given below :—

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
10.34—21.43%	0.59—4.90%	0.55—2.24%	35.61—46.87%	1.95—3.36%

The limestone throughout the entire distance along the escarpment is low in magnesia with SiO_2 mostly between 4% and 10%. The average thickness of the cement grade limestone is about 30 metres. The limestones exposed in the Ghaghar river can be utilised for the manufacture of cement by blending them with the escarpment limestone. The 60 m. thick limestone exposed in the Pataudh hill is suitable for cement manufacture.

A total of 25 million tonnes of limestone, suitable for the manufacture of cement has been estimated from the exposed portions of the escarpment sections by H. N. Singh and A. S. Dass (Roy, 1962 b, pp. 75-76) in the Makundi area between longitudes $83^\circ 07'$ and $83^\circ 21'$ and latitudes $24^\circ 31'$ and $30^\circ 37'$. Part of the limestone is suitable for use as flux.

In the eastern part of the belt grey, fine-grained limestone is exposed mainly in the escarpment sections between Kanach ($24^\circ 29' : 83^\circ 04'$) and Basuhari ($28^\circ 31' 30'' : 83^\circ 25'$) but at Kanach, Susnai ($24^\circ 28' : 83^\circ 13'$) and Jhiria ($24^\circ 30' : 83^\circ 18'$) it is also seen on flat land near the foot of the hill. The total thickness of the limestone varies from 30 to 90 m. with a general dip of 10° to 15° northwards. The variation in chemical composition of 40 samples of limestone from the eastern part of the Mirzapur district is given below :—

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
7.86—20.80%	0.40—3.37%	0.66—2.78%	34.06—46.15%	Trace—9.19%

Out of these 40 samples, four show less than 10% SiO_2 and 35 samples show less than 5% MgO .

The limestone bands between Kandhaura ($24^\circ 29' : 83^\circ 07'$) and Basuhar ($24^\circ 31' 30'' : 83^\circ 31' 00''$) are suitable for the manufacture of cement the SiO_2 content being between 8 and 10% and MgO being low. The limestone bands occurring between Kanach ($24^\circ 29' : 83^\circ 04'$) and Kandhaura ($24^\circ 29' : 83^\circ 07'$) are high in magnesia except at a few places.

The Kajrahat limestone zone extends from near Karamdand ($24^\circ 35' : 83^\circ 01'$) to south of Billi ($24^\circ 28' : 83^\circ 00'$) from where it extends upto Nawdiha ($24^\circ 26' : 83^\circ 16'$). Between Handi ($24^\circ 28' : 83^\circ 11'$) and Billi, limestone bands dip steeply but north of Billi the dips are between 10° to 15° towards the north-east. Out of ten samples analysed, three show MgO less than 3%, four show MgO between 3% and 5% and three show more than 5% MgO . SiO_2 varies between 9% and 12%. The Kajrahat limestone bands, occurring between hill 849 ($24^\circ 27' : 83^\circ 08'$) and a locality 3 km. east of it, are suitable for the manufacture of cement.

' ' As a result of mapping, drilling and trenching done by the Directorate of Geology and Mining, Govt. of U.P. the following possible reserves of Kajrahat limestone have been calculated from the Kota area.

Depth below surface	with 6% (SiO ₂ + Insol)	with 12% (SiO ₂ + Insol)
15 metres	2.5 million tonnes	10 million tonnes
30 metres	6.5 „	25 „

Encouraging results have also been obtained from Kajrahat and Dala areas. According to Krishna Mohan, the tentative reserves calculated would be of the order of 50 million tonnes. However, results so far obtained indicate the presence of large quantities of B.F. grade limestone in this area. The possibility of obtaining S.M.S. grade in the area appears to be meagre.

The Fawn limestone occurs on the left bank of the Son, almost parallel to the outcrop of Rohtas limestone and extends from Markundi (24°36' : 83°06') to Basuhari (24°31'30" : 83°30'00") for a distance of about 96.5 km. The Fawn limestone is not suitable for cement manufacture. The variation in chemical composition is as follows :

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO
2.92—8.64%	0.23—0.97%	1.03—2.17%	28.50—29.30%	17.80—20.20%

Deposits of crystalline limestone associated with calcitic bands are found near Bhimsura (24°07' : 82°50') and Belwadah (24°12' : 82°57'). Of these the former is dolomitic and the latter contains limestones of good quality. According to D. R. S. Mehta (1951) the Belwadah deposit contains 360,000 tonnes of calcite; 380,000 tonnes of coarse crystalline good limestone and 2,400,000 tonnes of crystalline dolomitic limestone. The variation in chemical composition in seven samples of the crystalline limestone from Belwadah is as follows :—

Insolubles	SiO ₂	R ₂ O ₃	MgO	CaO
0.48—0.52%	0.38—1.39%	0.20—1.00%	1.16—19.30%	30.85—53.96%

A sample of calcite from the same locality analyse :

Insolubles	R ₂ O ₃	MgO	CaO	Loss on Ignition
0.10%	0.10%	0.91%	54.96%	43.35%

According to M. V. N. Murthy (Krishnan, 1958, pp. 113-114) crystalline limestone bands occur in the following places : (i) About 800 m. S.S.W. of Ramtola (24°12' : 83°06'); (ii) About 3.0 km. west of Kathaundi immediately south of the quartzite ridge (24°06' : 83°06'); (iii) Two thin bands of limestone with E.—W. strike are exposed in the hill, about 1,200 m. NE of Kirwani (84°11' : 83°03'); (iv) Folded thin bands of crystalline limestone about 3 to 4 m. thick occur about 3 km. SE of Kirwani (84°11' : 83°03'); (v) About 1.5 km. N.W. of Bichhi (24°06'30" : 82°56'30"); (vi) Thin bands of coarse-serpentinous limestone, 8 m. thick, occur south of Dougia nala; (vii) About 3 km. grained serpentinous limestone, 8 m. thick, occur south of Dougia nala; (viii) About 3 km. N.W. of Garia (24°07'30" : 82°58'00") two bands of limestone about 100 m. wide extend for 150 m. In addition, there are also minor occurrences of limestone in the area. Since the limestone is highly magnesian, it is unlikely for use in the manufacture of portland cement. The reserves are estimated at four million tonnes.

Kedar Narain (Roy, 1964) examined the marble deposits near Ningha ($24^{\circ}26'$: $83^{\circ}00'$), Siur ($24^{\circ}27'$: $82^{\circ}59'$) and Obara ($24^{\circ}25'$: $82^{\circ}59'$). Bands of massive marble, pink and white to mottled green in colour occur in association with the brecciated quartzites of the Bijawar series.

S. M. Mathur (Krishnan, 1958, p. 84) reported the occurrence of calcite from about 3 km. north of Parsoi ($24^{\circ}26'$: $82^{\circ}54'$). Calcitic marble near Kusdand ($24^{\circ}09'$: $82^{\circ}54'$) is traceable for about 3 km. over a width of 500 m. Crystalline limestone bands also occur near Dhawadand ($24^{\circ}11'30''$: $82^{\circ}58'00''$).

Nainital district

Calc-tufa occurs around Chunakhan ($29^{\circ}19'$: $79^{\circ}15'$) in the Nainital district. The variation in chemical composition of eight samples of calc-tufa from this locality is given below :

SiO ₂	Al ₂ O ₃	CaO	MgO
0.46—10.36%	0.11—3.15%	32.10—53.41%	0.91—2.06%

The reserves of calc-tufa are of the order of 55,000 tonnes.

A tufa deposit has been recorded about 400 m. N. N. W. of Saulia ($29^{\circ}22'00''$: $79^{\circ}26'30''$). The deposit is 1.5 m. thick and occupies an area of 370 sq. metres. A reserve of 566 cu. metres of material have been estimated. Another calc-tufa deposit has been recorded E.N.E. of Adhaura ($29^{\circ}24'$: $79^{\circ}24'$). The variation in chemical composition of nine samples of calc-tufa from Saulia is given as follows :

SiO ₂	R ₂ O ₃	CaO	MgO
0.60—13.19%	0.86—10.69%	25.78—52.36%	1.36—20.52%

Limestone in the Kosi river area have been recorded from Jaurasi ($29^{\circ}31'00''$: $79^{\circ}31'30''$) through Bujan ($29^{\circ}30'30''$: $79^{\circ}29'00''$) and Baradhan Talla ($29^{\circ}32'00''$: $79^{\circ}25'30''$) up to Betalghat ($29^{\circ}33'30''$: $79^{\circ}21'00''$). The limestone bands are about 210 to 270 m. in thickness and are interbedded with slates. Two samples of this limestone analyse as follows :

SiO ₂	R ₂ O ₃	CaO	MgO
11.53% and 14.44%	6.05% and 2.60%	45.74% and 43.45%	0.29% and 1.94%

Calc-tufa occurs as a flat thick bed concealed under the soil at Lachhiwala. The reserves have been estimated at 0.51 million tonnes. One representative sample analyses 52.26% CaO, trace of MgO, 1.42% R₂O₃ and 3.26% of insoluble residue.

Tehri Garhwal district

According to Swaminath (Krishnan, 1958, p. 118) limestone bands at Nagni ($30^{\circ}19'$: $78^{\circ}21'$) are of lenticular nature. Bands and lenses of high grade limestone and dolomite are intercalated with impure varieties. Four out of 18 samples analysed, are suitable for cement and chemical manufacture and six samples are of good dolomite suitable for furnace lining. The variation in chemical composition of 17 samples of limestone is given as follows :—

CaO: 23.04—58.08%	MgO: 0.72—21.47%
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Occurrences of massive, dark, blue limestone are also reported by A. K. Zuberi (1956) from Dholapani and Agrakhal near Narendranagar in Tehri Garhwal district.

REFERENCES

- KRISHNAN, M., 1958.—General Report for 1954. *Rec. Geol. Surv. Ind.*, Vol. 88, Pt. 1, p. 84.
- , 1958.—General Report for 1952-53. *Rec. Geol. Surv. Ind.*, Vol. 87, Pt. 1, pp. 113-114.
- MEHTA, D. R. S., NARAYAN MURTHY, B. R. & NARSIMHAM, A. S., 1959.—High grade limestone deposits, Dehra Dun Area. *Bull. Geol. Surv. Ind.*, Ser. A, No. 16.
- MEHTA, D. R. S., 1951.—A note on the crystalline limestone deposits at Belwadah, Mirzapur district, U.P. *Bull. Geol. Surv. Ind.*, Ser. A, No. 8.
- , A note on the limestone deposits at Markundi, Robertsganj area, Mirzapur district, U.P. *Bull. Geol. Surv. Ind.*, Ser. A, No. 2.
- MOHAN, KRISHNA, 1962.—Minerals in Uttar Pradesh and their Development, and Recent activities of Directorate, *Ind. Min.*, Vol. 16, No. 1, p. 24-26.
- MOHAN, KRISHNA & PRAKASH, RAVI, 1956.—Report on the Glass sand, Gypsum, limestone, Phosphatic rocks and Auriferous sands occurring in parts of Dehra Dun district, Directorate of Geology & Mining, U.P. (Unpublished).
- NATH, MUKTA, 1951.—Limestone deposits of the Son Valley, Mirzapur district, U.P. and their suitability for cement and carbide. *Bull. Geol. Surv. Ind.*, Ser. A, No. 2.
- PRAKASH, RAVI and ZUBERI, A. K., 1957.—Preliminary Report on the limestone deposits near Nilkantha, Garhwal district, Directorate Geology & Mining, U.P. (Unpublished).
- ROY, B. C., 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.*, Vol. 95, Pt. 1.
- , 1962 a.—General Report for 1957. *Rec. Geol. Surv. Ind.*, Vol. 92, Pt. 1.
- , 1962 b.—General Report for 1959. *Rec. Geol. Surv. Ind.*, Vol. 94, Pt. 1.
- , 1961.—General Report for 1955. *Rec. Geol. Surv. Ind.*, Vol. 89, Pt. 1.
- SWARUP PREM and RANHOTRA, H. S., 1960.—Report on the Tirohan limestone near Karwi, Banda district, Directorate of Geology & Mining, U.P. (Unpublished).
- ZUBERI, A. K., 1956.—Preliminary report on limestone deposits at Dholapani and Agarkhaj, Tehri-Garhwal district. Directorate of Geology & Mining, U.P. (Unpublished).

LOCALITY INDEX

Almora district :

Latitude : Longitude

Chaukhutia	29°50' : 79°20'
Dhanpur	20°13' : 79°06'
Dwarahat	29°47' : 79°26'
Ganpurgarh	30°0' : 79°20'
Monwa Devi	29°52' : 79°25'

Banda district :

Karwi	25°14' : 80°55'
Chauri	24°50'15" : 80°54'40"

Chamoli district :

Kindola khal	30°38' : 78°55'
Kund Chatti	30°30' : 79°06'

Dehra Dun district :

Sisoli	30°23' : 78°08'
Sahasradhara	30°22'55" : 78°07'50"
Jharipani	30°26'30" : 78°05'50"
Jud	30°23'45" : 78°06'30"
Bhatta	30°21'30" : 78°07'55"
Hathipaon	30°27'15" : 78°01'40"
Cloud End	30°27'50" : 78°00'35"
Kerwan	30°24'40" : 78°06'30"
Hill Δ 6748	30°27'00" : 78°01'40"
Mussoorie	30°25' : 78°00'
Armigad stream	30°25' : 78°06'
Kalsi	30°00'30" : 77°50'00"
Barkot	30°17' : 78°15'
Deoban Hill	30°45' : 77°50'
Chakrata	30°38'00" : 77°45'30"

LOCALITY INDEX—*contd.*

<i>Garhwal district:</i>	Latitude : Longitude
Nilkanth	30°40' : 79°20'
Toli	30°36' : 78°22'
Bhadsi	30°06' : 78°21'
Tila	29°12' : 79°06'
Guar	30°14' : 79°07'
<i>Mirzapur district:</i>	
Silpi	24°37' : 82°50'
Basuhari	24°31'30" : 83°50'00"
Gurdah	24°36' : 82°59'
Kota	24°37' : 82°50'
Hirakhair	24°37' : 82°55'
Alaur	24°37' : 82°57'
Rijul	24°37' : 82°50'
Jamna	24°38' : 82°51'
Kanach	24°29' : 83°04'
Belwa	24°37' : 82°54'
Markundi	24°36' : 83°06'
Makribari	24°35' : 83°08'
Rudauli	24°36' : 83°08'
Belach	24°33' : 83°07'
Pataudh	24°32' : 83°05'
Kandhaura	24°29' : 83°07'
Billi	24°28' : 83°00'
Nawdiha	24°26' : 83°16'
Hardi	24°28' : 83°11'
Hill 849	24°27' : 83°08'
Kajrahat	24°25' : 83°00'
Bhimsura	24°07' : 82°50'
Belwadah	24°12' : 82°06'
Ramtola	24°12' : 83°06'

LOCALITY INDEX—*concl.**Mirzapur district—contd.*

	Latitude	Longitude
Kirwani	24°11' : 83°03'	
Bichhi	24°06'30" : 82°56'30"	
Garia	24°07'30" : 82°58'00"	
Ningha	24°26' : 83°00'	
Obera	24°25' : 82°59'	
Parsoi	24°26' : 82°54'	
Dhawadand	24°11'30" : 82°58'00"	

Nainital district :

Chunakhan	29°19' : 79°15'	
Saulia	29°22'00" : 79°26'30"	
Adhaura	29°24' : 79°24'	
Jaurasi	29°31'00" : 79°31'30"	
Bajan	29°30'30" : 79°29'00"	
Baradhan Talla	29°32'00" : 79°25'30"	

Fehri Garwal district :

Nagni	30°19' : 78°21'	
Narendranagar	30°05' : 78°15'	

WEST BENGAL

Bankura district

According to P. K. Chatterjee (1954), six separate exposures of crystalline limestones occur in the gneissic country lying S.S.E. and E.S.E. of of Harirampur (23°8' : 86°45') and S.S.W. of Guniada hillock (Δ 684 ; 23°09' : 86°45'). The Guniada band is 30 metres long and 8 m. wide. The Harirampur band is 66 m. long and 10 m. wide. Another prominent strip of limestone occurs about 4 km. east of the cart track from eastern Harirampur to Salaipahari (23°08' : 86°46'), measuring about 295 m. long and nearly 90 m. wide.

The variation in chemical composition of these limestones is given below :

Insolubles	SiO ₂	R ₂ O ₃	CaO	MgO	Loss on ignition
7.64-14.54%	2.06-13.62%	2-2.4%	30.85-36.49%	11.13-20.34%	36.38 44.86%

The limestones in this area are mainly dolomitic in character. The reserves are estimated at 1.9 million tonnes down to a depth of 15 m.

A. Hunday (Krishnan, 1954, pp. 110-111) reported a small occurrence of impure crystalline limestone, 3 m. long and 2.5 m. wide, near the Mangalagara nadi section about 800 m. west of Chanpabani village (22°50' : 86°56').

He also reported the local development of *kankar* in the alluvial country towards the east, viz., the banks of Kasai river east and south-east of Raipur (22°47' : 86°57') and of Bansir nadi where the material is used for the manufacture of quick lime.

Darjeeling district

T. K. Kurien (Roy, 1964) reported the presence of calc-tufa at the Gondwana-Siwalik junction to the south of Latpancher (26°54' : 88°24') and in Gola and Andhera blocks of Sukna and Tista Reserved Forests. These occurrences are limited and are of no economic importance.

Jalpaiguri district

According to Kurien (1959), limestone in the Siwaliks and Buxa formations constituting the Himalayan foothills occurs on the north-eastern corner of the Jalpaiguri district. In the Siwalik sandstones and shales, only three discontinuous bands of limestone occur. The deposits as a whole are dolomitic in composition.

Lahiri (1941) reported large masses and boulders of calcareous tufa found abundantly in the Jainti River gorge and other associated stream courses. A sample analyses CaO—53.8% ; MgO trace ; Insolubles—2.3% ; Fe₂O₃ and Al₂O₃—trace.

Thin and impersistent bands of crystalline limestone occur about 800 m. south-west of Adma ($26^{\circ}46' : 89^{\circ}33'$).

Purulia district

(1) *Digardih area* ($23^{\circ}28' : 85^{\circ}52'$).—In this area, limestones occur in six isolated patches, the longest outcrop at Ichatu ($23^{\circ}28' : 85^{\circ}53'$) is 540 m. long while the smallest one is 66 m. long. The limestone and marble occur intercalated with quartzite and calc-gneiss. The individual thickness of the limestone bands varies from a few centimetres to about six metres.

The reserves of all bands including the space occupied by solution cavities in the Digardih area come to about one million tonne down to a working depth of 30 m. (G. N. Dutt, 1959).

The limestones are high in silica but low in magnesia, alumina and iron oxide. The average content of insolubles is 34.02 per cent.

(2) *Jabar* ($23^{\circ}27' : 86^{\circ}30'$) *area*.—The marble bands are intercalated with quartzites and numerous thin bands of biotite-quartzite-schist, and gneissose calc-silicate beds. According to T.M. Mahadevan (1956-57), the width of the entire lime zone of these rocks varies from 45 to 90 m. The zone of limestone and interbanded biotite-quartzite-schist extends for about 1200 m. along the slope of the Jabarban hill and further to the west, for about 400 m. Two varieties may be distinguished (a) relatively purer lenses, 1—1.5 m. wide and traceable for 9 to 12 m. in length and (b) fine-grained limestone with foliae of biotite.

The chemical analyses show SiO_2 content ranging from 36.2 to 54.88 per cent and MgO content ranging from 2.18 to 2.89 per cent. The samples collected from the relatively purer portions show 7.99 to 29.28 per cent SiO_2 , traces of magnesia and 39.01 to 50.08 per cent CaO .

The reserves of limestone have been estimated at two million tonnes down to a depth of 30 m. (G. N. Dutt 1959.)

(3) *Belamu area* ($23^{\circ}27'40'' : 86^{\circ}30''$).—The Belamu outcrop is situated about 4 km. due east of main Jabar marble on the south-western flank of Belamu hill (Δ 1939). The length of the limestone zone is about 150 m. and the width is about 15 m. at its maximum. The reserves have been estimated at 25,000 tonnes down to a depth of 15 m. The average insoluble content is 31.58 per cent.

(4) *Maramu area* ($23^{\circ}29' : 86^{\circ}30'$).—The general run of the limestone band is east-west for a length of 140 m. and the width is about 27 m. The reserves are estimated at 22,000 tonnes down to a depth of 15 m. with an average content of 26.91 per cent insolubles.

(5) *Simni area* ($23^{\circ}28' : 86^{\circ}00'$).—The marble at Simni hill is about 150 m. long. The aggregate width of all marble bands put together is about five metres. The reserves are estimated at 23,000 tonnes down to a depth of 15 m. with 33.54 per cent insolubles.

According to Roy (1938), an outcrop of massive dark grey coloured bedded limestone occurs at the western extremity of Panchet hill ($23^{\circ}38' : 86^{\circ}45'$). The deposit extends over a length of 180 m. and has a thickness of about six metres. The reserves of limestone over this length and to a depth of 90 m.

amount to 250,000 tonnes. The limestone analysed as CaCO_3 —45.05 to 65.03% ; MgCO_3 —3.78 to 14.41% and insolubles—19.28 to 29.28%.

A few other deposits of impure limestone of concretionary nature are also found in the immediate vicinity.

Few deposits of crystalline limestone have also been reported from south-west of Kukur (22°51' : 86°23'). Tamakhun (22°59' : 86°36'), Gobindpur (22°58' : 86°39'), Mirichanda (22°58' : 86°41') and Kumari (22°58' : 86°38').

REFERENCES

- CHATTERJEE, P. K., 1954.—Progress Report for 1953-54, G.S.I. (Unpublished).
- Dutt, G. N., 1959.—Some limestone occurrences in the Purulia district, West Bengal, G.S.I. Report (Unpublished).
- Kaishnan, M. S., 1953.—General Report for the year 1950; *Rec. Geol. Surv. Ind.* Vol. 84, Pt. 1, p. 83.
- 1954.—General Report for 1952; *Rec. Geol. Surv. Ind.* Vol. 86, Pt. 1.
- KURJEN, T. K., 1959.—A note on the investigation of limestone for cement in Jalpaiguri district, G.S.I., (Unpublished).
- LAHM, A., 1951.—Geology of Buxa Duars. *Geol. Min. Met. Soc. Ind.* Vol. 13, No. 1, Pt. 1, p. 57-58.
- MAHADEVAN, T. M., 1956-57.—Report on the limestone occurrences near Jhalda Purulia district, West Bengal, G.S.I. Report (Unpublished).
- ROY, B. C., 1938.—Economic Geology of Panchet Hill. *Geol. Min. Met. Soc. Ind.* Vol. 10, No. 4, p. 241.
- 1964.—General Report for 1960. *Rec. Geol. Surv. Ind.* Vol. 95, Pt. 1, p. 150.
- SASTRY, C. K. R., 1950-51.—Progress Report for 1950-51, G.S.I. (Unpublished).

LOCALITY INDEX

Bankura district :

Latitude : Longitude :

Harirampur	23°08' : 86°45'
Giuniada hillock Δ 684	23°09' : 86°45'
Salaipahari	23°08' : 86°46'
Champabani	22°50' : 86°56'
Raipur	22°47' : 86°57'

Darjeeling district :

Latpancher	26°54' : 88°24'
Sukna	26°45' : 88°20'

Jalpaiguri district :

Adma	26°46' : 89°33'
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Purulia district :

Digardih	23°28'15" : 85°52'20"
Ichatu	23°28' : 85°53'
Jabar	23°27' : 86°30'
Belamu	23°27'40" : 86°2'30"
Maramu	23°28'50" : 86°30'00"
Simui	23°28' : 86°00'
Panchet hill	23°38'20" : 86°45'20"
Kukru	22°51' : 86°23'
Tamakhun	22°51' : 86°33'
Gobindpur	22°58' : 86°39'
Mirgichanda	22°58' : 86°41'
Kumari	22°58' : 86°38'



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